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4 Vols.

by R P Rastogi and B N Mehrotra

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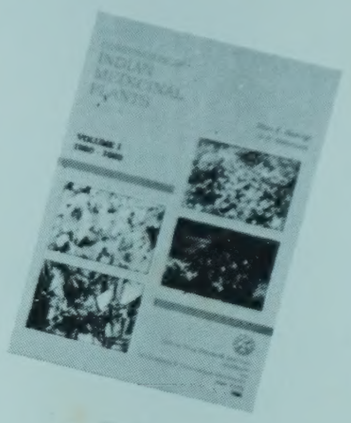

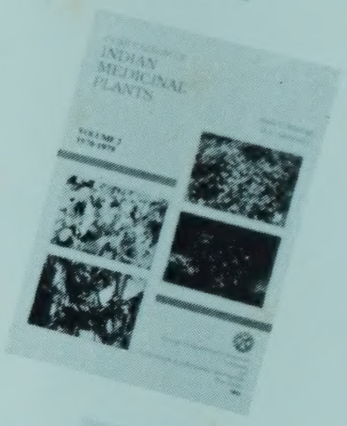

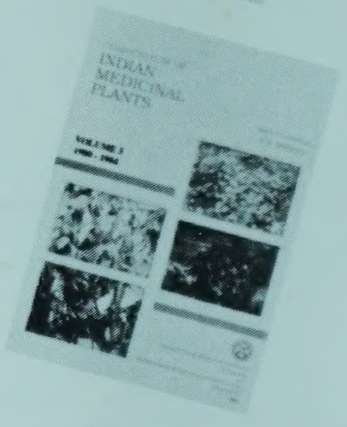

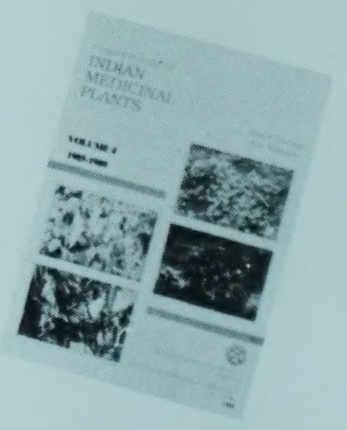

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Journal of Scientific & Industrial Research

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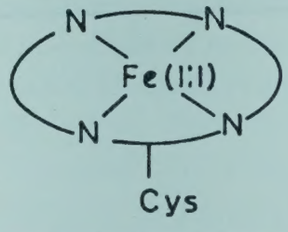

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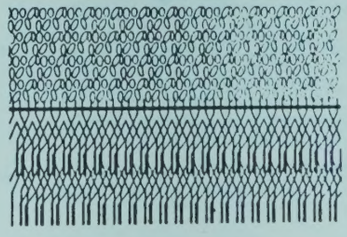

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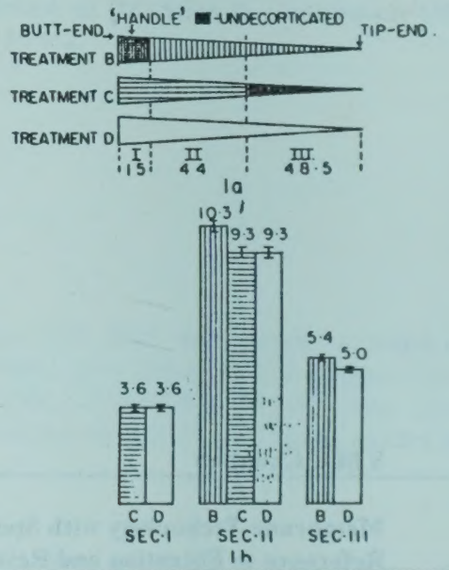

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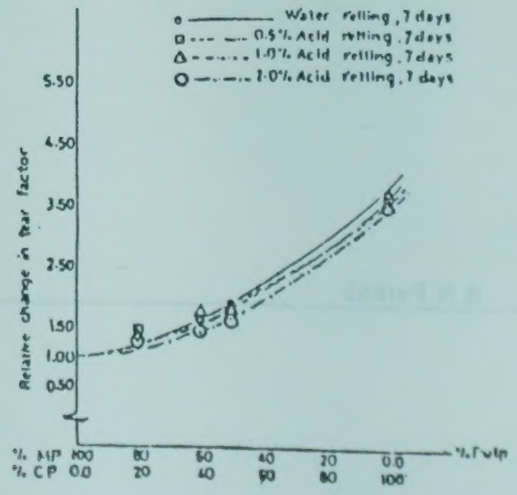

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Journal of Scientific & Industrial Research
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Oxygenations of Terpenoids, Nitrogen Heterocycles, Phenolics and Related Compounds with Chemical Models for Selected Monooxygenases#

S.M.S. Chauhan

Department of Chemistry, University of Delhi, Delhi 110 007, India

Oxygenations and oxidations of some terpenoids, nitrogen heterocycles, phenolics and other organic compounds with a few selected natural monooxygenases and their chemical model systems have been reviewed. The oxygenation of non-polar compounds, oxidative phenol coupling, demethylation of alkaloids and selected rearrangement reactions mimicked by different chemical model systems for cytochrome P450 and related monooxygenases are presented. The oxygenation of nitrogen heterocycles and other electron rich compounds obtained by flavin monooxygenases as well as heme monooxygenases are described. The hydroxylation of aromatic amino acid and related aromatic compounds achieved by chemical model for pteridine monooxygenases is discussed. The chemical cleavage of DNA and oxidation of selected fine chemicals, newer metabolites of drugs, pesticides, carcinogens and pollutants achieved by using selected chemical model systems in different reactions are highlighted. It is pointed out that these mild catalytic reactions are eco-friendly and may be used for control of pollution in chemical industry.

Introduction

Oxygenation of endogenous and exogenous substrates is one of the most important reactions in biological systems. The incorporation of one or two atoms of molecular oxygen into substrates is called oxygenation and it is catalyzed by a group of enzymes known as oxygenases[1]. These enzymes are classified into monooxygenases [Eq.(1)] and dioxygenases [Eq.(2)], depending on the incorporation of one or two oxygen atom into substrates[2].

$$XH + O_2 + AH_2 \rightarrow XOH + H_2O + A \quad ...(1)$$

$$XH + O_2 \rightarrow XO_2H \quad ...(2)$$

where XH and AH_2 represent substrate and electron donor, respectively.

Monooxygenase requires two electrons to reduce the second oxygen atom of dioxygen to water. Since monooxygenases function both as oxygenase and oxidase, they are also called "mixed function oxidases" or "mixed function oxygenases". The transfer of two electrons from external sources such as NADPH or NADH is called external monooxygenases, whereas transfer or removal of two electrons from substrate itself is called internal monooxygenases. The monooxygenases are further classified into heme[3] or non-heme monooxygenases[4-6]. The non-heme monooxygenases are further subclassified into non-heme iron monooxygenases[7-10] and non-heme non-iron containing monooxygenases[11]. Since most of the monooxygenases are membrane bound and are difficult to isolate in large quantities for chemical synthesis and industrial applications, the development of chemical models for these monooxygenases and their reactions constitutes an important area from scientific as well as industrial point of view. Some of these aspects are presented in this article.

#Based on the Prof.R.C.Shah Memorial Award Lecture for 1996-97 delivered by Prof. S.M.S. Chauhan for 1996-97 at 84th Session of Indian Science Congress Association on 7 January 1997 at the Universityi of Delhi, Delhi.

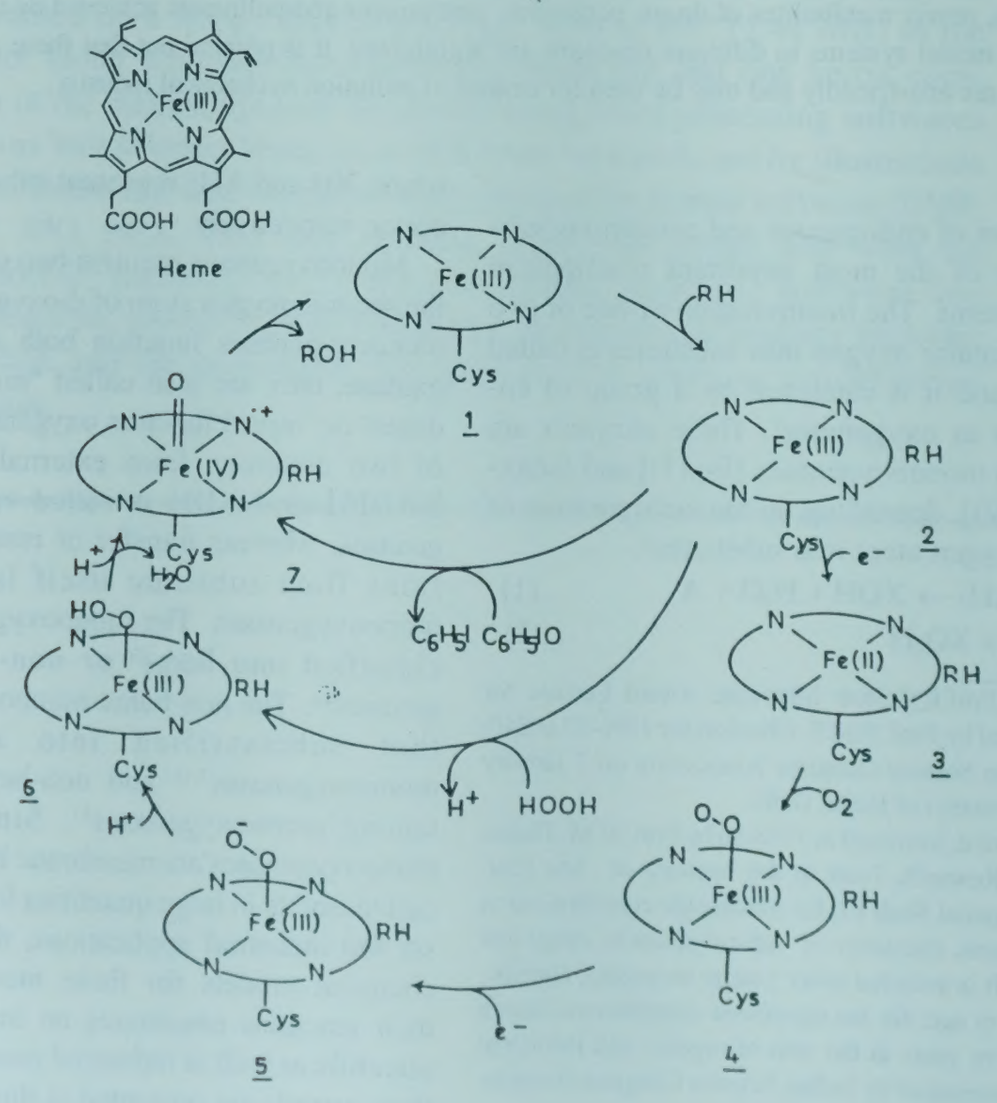
The lecture award, instituted in 1995-96 by Prof. V.M. Thakar Education and Research Trust in the memory of late Prof. Ramanlal Chhaganlal Shah for his remarkable contributions in the areas of organic chemistry of natural products, drugs and fine chemicals. It is awarded every year to an organic chemist, below 45 years in age, for his significant contributions during the preceding five years in the area of organic and medicinal chemistry. It is managed by Indian Science Congress Association (ISCA).

Chemical model systems are emerging as important tools in the chemical nucleases of DNA and in the biosynthesis of natural products. Chemical models with different permutations of metalloporphyrins, monooxygen donors and suitable reaction media may afford efficient methods for effluent treatment, synthesis of fine chemicals and active oxidative metabolites of drugs and pesticides in industry.

Chemical Models for Different Monooxygenases

Cytochromes P450 are heme containing monooxygenases which catalyze the activation of molecular oxygen incorporating one atom of oxygen into an organic substrate with concomitant reduction of the other atom to water. Cytochrome P450 supergene family has been classified on the basis of their evolutionary relationship[12]. The nomenclature of individual cytochrome P450 is based on the homology of the amino acid sequences. This nomenclature does not indicate the properties or functions of individual cytochrome P450. Initially, cytochrome P450 might have been evolved for the biosynthesis and metabolism of endogenous substrate, cholesterol to maintain membrane integrity, biosynthesis and metabolism of steroidal compounds than the metabolism of foreign compounds. The xenobiotic cytochrome P450 was evolved from steroidogenic cytochrome P450 for enhancing the animal survival by synthesizing new cytochrome P450 for metabolizing the plant toxins and other foreign compounds[13,14].

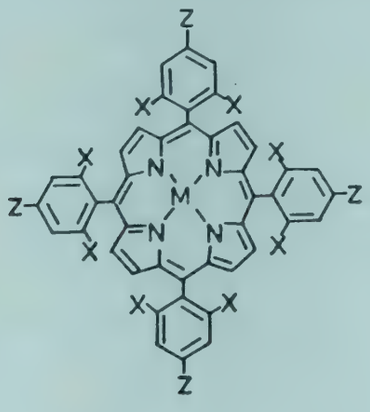
The iron(III) protoporphyrin IX with thiolate axial ligand constitutes the prosthetic group in the resting state of cytochrome P450 (**1**) (Scheme 1). The natural cytochrome P450 binds with substrate to form a substrate-cytochrome P450 complex (**2**). The cytochrome P450 reductase reduces the iron(III) complex of substrate to iron(II) form of cytochrome P450 (**3**)



Scheme 1 — Catalytic cycle of natural cytochrome P450

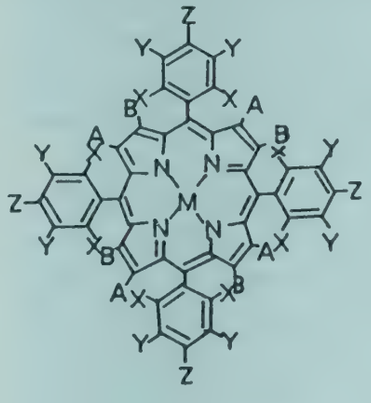
The dioxygen binds to iron(II) form of substrate-cytochrome P450 complex **3** to give peroxy radical **4** which on reduction with cytochrome P450 reductase produces the intermediate **5** and subsequently in the presence of proton source forms a peroxy intermediate **6**. The heterolytic cleavage of O-OH bond of **6** forms the high valent oxo- iron complex **7** which is responsible for transfer of single oxygen atom to substrate (Scheme 1). This catalytic cycle is known as 'Long Catalytic Cycle' of cytochrome P450. The resting state of iron(III) cytochrome P450 (**1**) reacts with monooxygen donors to form the high valent oxoiron(III) complex which transfers oxygen to substrate. This catalytic cycle is known as 'Short Catalytic Cycle' of cytochrome P450[15,16] (Scheme 1). The high valent oxoiron(IV) porphyrin radical cations (**7**) are similar to the compound **1** in Horse Radish Peroxidase(HRP)[17] and the high valent oxoiron(IV) porphyrin is similar to compound **2** of HRP[17]. The chemical and spectral properties of metallo 5,10,15,20- tetraarylporphyrins (TAPs) do not differ much from the corresponding natural metalloporphyrins. The synthesis of metallo TAPs, specially Mn(III) and Fe(III), is relatively easier and is more stable towards many oxidants than their natural counterparts. Hence, the use of metallo TAPs (**8-18**) is preferred than that of natural metalloporphyrins in biomimetic oxidation reactions (Chart 1). The cyclo-condensation of aryl aldehydes with pyrrole in propionic acid is an important method for the synthesis of symmetrical porphyrins[18,19]. The sterically hindered and electron withdrawing 5,10,15,20-teraarylporphyrins are prepared in moderate yields by borontrifluoride-etherate and subsequent oxidation in chloroform[20,21]. The 5,10,15,20- tetraarylporphyrinatomanganese(III)chlorides [TAPMn(III)Cl (**9a- 15a**)] are prepared by the reaction of free base porphyrins with manganese(II)chloride in DMF[22]. Similarly, 5,10,15,20- tetraarylporphyrinatoiron(III)chlorides (**9b-15b**) are prepared by the reactions of free base porphyrins with iron(II) chloride in DMF[22] (Chart 1). The 2,3,7,8,12,13,17,18-octahalogenated- 5,10,15,20-tetraarylporphyrinatomanganese(III) and corresponding iron(III) chlorides are more robust in oxidative conditions and are efficient catalysts than simple 5,10,15,20- tetraarylporphyrinatomanganese(III) and iron(III) chlorides[23,24].

The β-perhalogenated 5,10,15,20-tetraarylporphyrins have been prepared by the halogenation of free base 5,10,15,20- tetraarylporphyrins as well as the corresponding zinc or copper 5,10,15,20-tetraarylporphyrins[25]. The required Mn(III) and Fe(III) perhalogenated 5,10,15,20-tetraarylporphyrins [**15a-18a** and **15b-18b**, respectively] have been prepared by modifying the known proce-



a, M=Mn(III)Cl
b, M=Fe(III)Cl

8, X=Z=H
9, X=Cl, Z=H
10, X=Z=CH_3
11, X=H, Z=CH_3
12, X=Br, Z=H
13, X=NO_2, Z=H



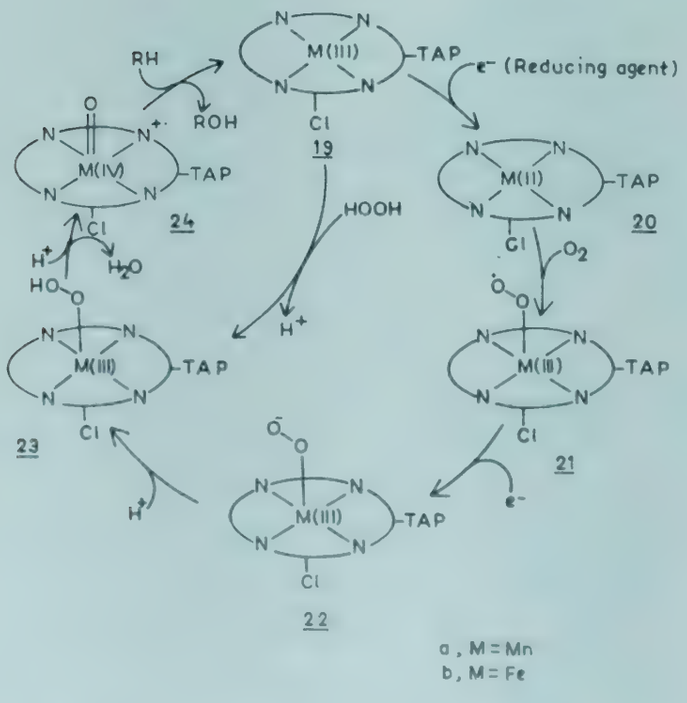
a, M=Mn(III)Cl
b, M=Fe(III)Cl

14, X=Y=Z=F, A=B=H
15, X=Y=Z=Cl, A=B=H
16, X=Y=Z=H, A=B=Br
17, X=Cl, Y=Z=H, A=B=Br or Cl
18, X=Z=CH_3, Y=H, A=B=Br or Cl

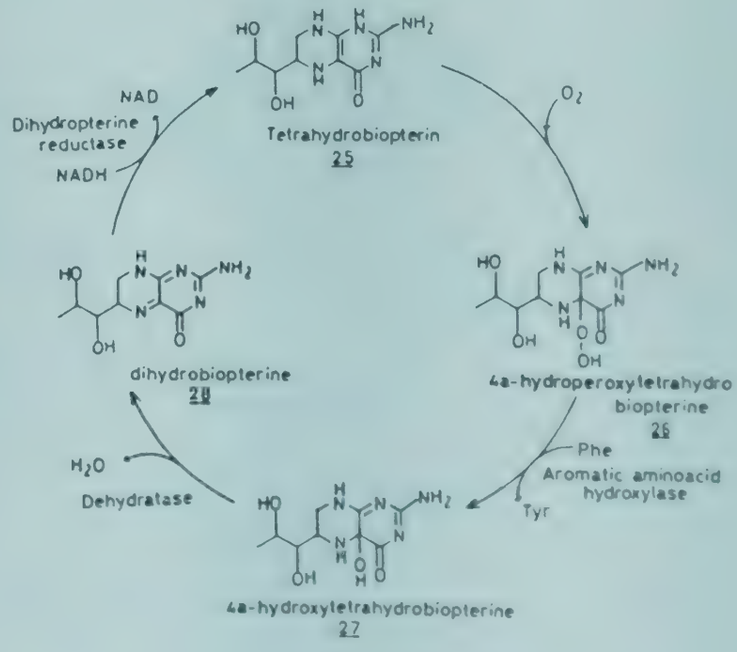
Chart 1 — Selected lipid soluble Fe(III) and Mn(III)- 5,10,15,20- tetraarylporphyrins

dures[26,27] (Chart 1). Different reducing agents reduce the synthetic metallo(III) porphyrins (**19**) to metal(II) porphyrins (**20**) which react with molecular oxygen to form the intermediate **21**. The reduction of **21** produces another intermediate **22** which in the presence of a proton source and heterolytic cleavage forms high valent oxometalloporphyrin radical cations (**24**) that transfer single oxygen atom to substrates[28-30] (Scheme 2). This cycle is called Long Catalytic Cycle of chemical model for cytochrome P450. H_2O_2 reacts with metalloporphyrin (**19**) and forms the intermediate **23** which on heterolytic cleavage forms the high valent oxometalloporphyrin (**24**). Similarly, iodosylbenzene directly reacts with **19** and forms the high valent oxo metalloporphyrin **24**. This is called "Short Catalytic Cycle" of chemical model for cytochrome P450. This formation of high valent oxometalloporphyrins and transfer of monooxygen to organic substrates alike to high valent oxoiron species of cytochrome P450 is known as chemical model of cytochrome P450[15,16].

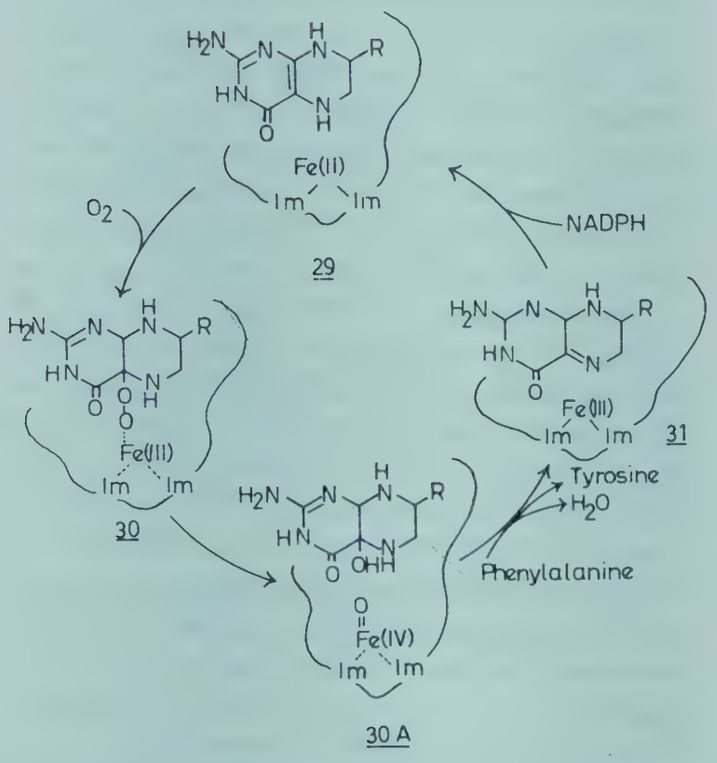
The study of structures and functions of high valent oxoiron porphyrins has contributed to the understanding of structures and functions of different isoforms of natural cytochrome P450. Phenylalanine hydroxylase is an important example of non-heme iron containing monooxygenase. The aromatic aminoacids, including phenylalanine, tyrosine and tryptophan are hydroxylated with aromatic aminoacid hydroxylases through utilization of molecular oxygen and NADPH[31,32]. The 5,6,7,8-tetrahydropterine is a cofactor in L-phenylalanine and other aminoacid hydroxylases. Tetrahydrobiopterin dependent monooxygenases are regulators in the metabolism of aromatic aminoacids and mediators for the maintenance and proper functioning of brain. The tetrameric mammalian phenylalanine hydroxylase contains one non- heme iron per monomer, while the monomeric phenylalanine isolated from *Chlorobacterium violaceum* contains a single type II copper with two coordinated histidyl imidazoles in the Cu(II) and Cu(I) states. The reaction of 5,6,7,8-tetrahydropterine (**25**) with molecular oxygen forms 4a-hydroperoxy biopterine intermediate **26** which hydroxylates phenylalanine to tyrosine[31,32] and forms 4a- hydroxytetrahydropterine (**27**). The removal of water from **27** in the presence of carbinol-amine dehydratase gives an intermediate **28** which on reduction with NADPH gives the tetrahydrobiopterin **25** (Scheme 3). In mammalian hydroxylase one mole of iron is bound to the active site of phenylalanine hydroxylase. One electron from reduced pteridine is transfered to Fe(III) and the second to molecular oxygen leading to the intermediate **30**. It is proposed



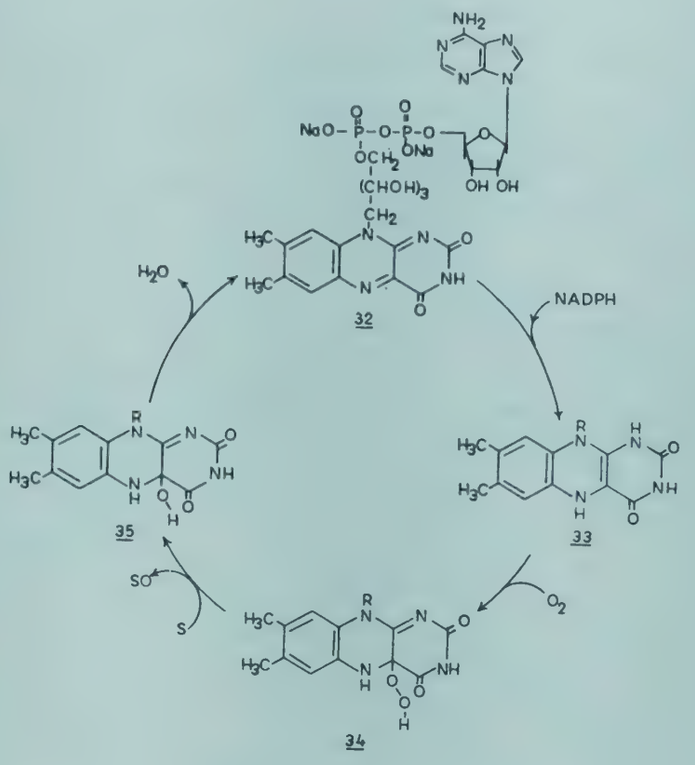
Scheme 2 — Catalytic cycle of cytochrome P450 chemical model system



Scheme 3 — Catalytic cycle of aromatic aminoacid hydroxylases



Scheme 4 — Role of iron bound to active site of aromatic aminoacids



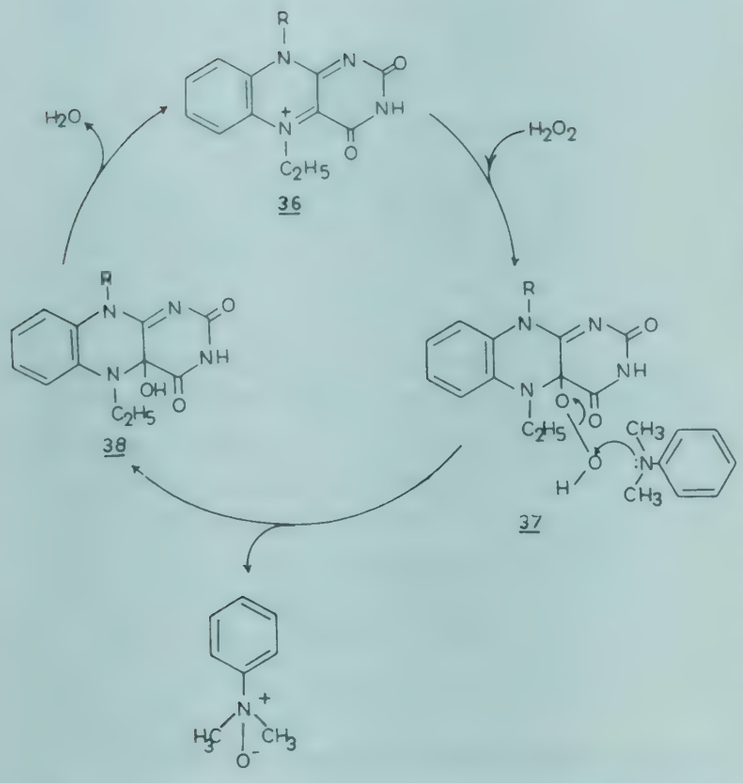
Scheme 5 — Catalytic cycle of flavomonooxygenase

that enzyme bound oxoiron intermediate (**30A**) is responsible for the transformation of phenylalanine to tyrosine[33] (Scheme 4). The 5,6-dimethylpterin reacts with H_2O_2 in the presence of an acid to form the hydroperoxyintermediate which transfers monooxygen to phenylalanine and forms tyrosine in moderate yields under different reaction conditions[34]. Chemical models for the iron bound enzyme have been developed by the reaction of iron complex formed with tetrahydro-5,6-dimethylpterine and 2,2′-bipyridine with molecular oxygen and phenylhydrazine which hydroxylates phenylalanine to tyrosine in moderate yields in an acidic buffer[35]. The 5,6,7,8- tetrabiopterins also function as essential enzyme cofactors in the conversion of tyrosine to DOPA, in melanine synthesis and in tryptophan hydroxylation.

The flavin monooxygenase is an important example of non-heme non- iron monooxygenase. Many electron rich nitrogen heterocycles, drugs and related compounds are metabolized by microsomal flavin monooxygenases[11] through utilization of molecular oxygen and NADPH in biological systems (Scheme 6). Flavin monooxygenases exhibit broader substrate specificities and a distinct mechanism than cytochrome P450. The flavin adenine dinucleotide is the prosthetic (**32**) group of a flavin monooxygenase which is reduced by NADPH to give dihydroderivative **33**. The reaction of **33** with molecular oxygen gives the hydroperoxyintermediate **34**. The nucleophilic attack of substrate to electrophilic hydroperoxyintermediate **34** forms the oxygenated product and hydroxy flavin **35** which on elimination of water gives theresting state **32** of flavoenzyme (Scheme 5).

Chemical models for flavin monooxygenases have been developed by the reactions of synthetic flavins (**36**) with molecular oxygen in the presence of reducing agents to obtain the hydroperoxy intermediate (**37**). The reaction of N,N-dimethyl aniline with **37** gives N,N-dimethyl aniline-N-oxide and 4a-hydroxyflavin (**38**) which on removal of water produces back the parent flavin[36] (Scheme 6). The reactivity of hydroperoxyflavin is expected to resemble with metal hydroperoxides, hence reaction of metal hydroperoxides toward amines are examined. Metal hydroperoxide are formed by either treating metals with H_2O_2 or oxidising metal hydride with molecular oxygen[37,38].

Terpenoids, alkaloids and phenolics are important and widely distributed secondary metabolites. The oxidation of selected secondary metabolites by both



Scheme 6 — Chemical model for flavomonooxygenase

natural monooxygenases and their chemical model systems has been described in the following sections. The reactions catalyzed by natural monooxygenases have been compared with chemical models to improve the selectivity and reactivity of chemical models for the above monooxygenases.

Biosynthesis and Oxygenation of Terpenoids

Terpenoids are most abundant and widely distributed natural products. The primary metabolites of terpenoids serve as hormones, membrane components and photoreceptor products, whereas secondary metabolites serve as defence against herbivores and pathogens, allelopathic interactions and pollination attractors in higher plants[39,40].

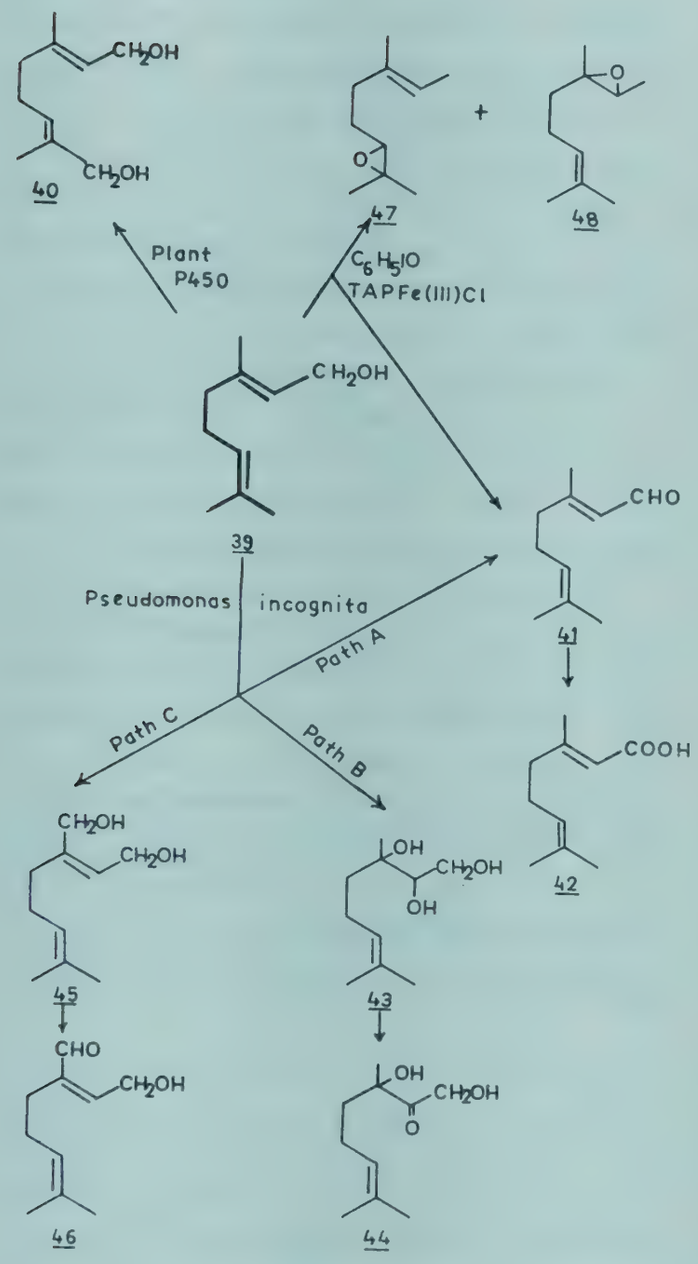
Oxygenation of Monoterpeniods and Related Compounds

Plant cytochrome P450 catalyzes hydroxylations, epoxidations and other oxygenation reactions in terpenes and terpenoids and are responsible for biochemical taxonomical variations in plants[41,42]. The oxygenation of monoterpene geraniol (**39**) with partially purified plant cytochrome P450 to product (**40**) was the first example of the use of plant cytochrome P450 in the oxidation of terpene and terpenoids[43,44]. The oxidation of **39** by *Pseudomonas incognita* produces different products which may be arranged chemically in three different pathways. Path (**A**) involves the oxidation of primary alcohol to an aldehyde (**41**) and subsequently to an acid (**42**). Path **B** involves the oxidation of 2,3- double bond to products **43** and **44** and Path **C** involves the oxygenation at C-10 methyl group[45] to products **45** and **46** (Scheme 7). The oxygenation of geraniol with iodosylbenzene catalyzed by $Cl_8TPPFe(III)Cl$ in aqueous SDS micelle gives geranial (**41**) and geranic acid (**42**), whereas both 6,7-epoxygeraniol (**47**) and 2,3-epoxygeraniol (**48**) are obtained in CTAB micelles in moderate yields[46] (Scheme 7). A comparison of enzymatic reactions with model reactions suggests that the oxidation products and their yields in biomimetic oxidation reactions may be changed by modification in the reaction media. Cytochrome P450 are involved in the biosynthesis of epoxide ring in different Juvenile Hormones (JH) which govern the neurohormonal control of development and reproduction in insects[47].

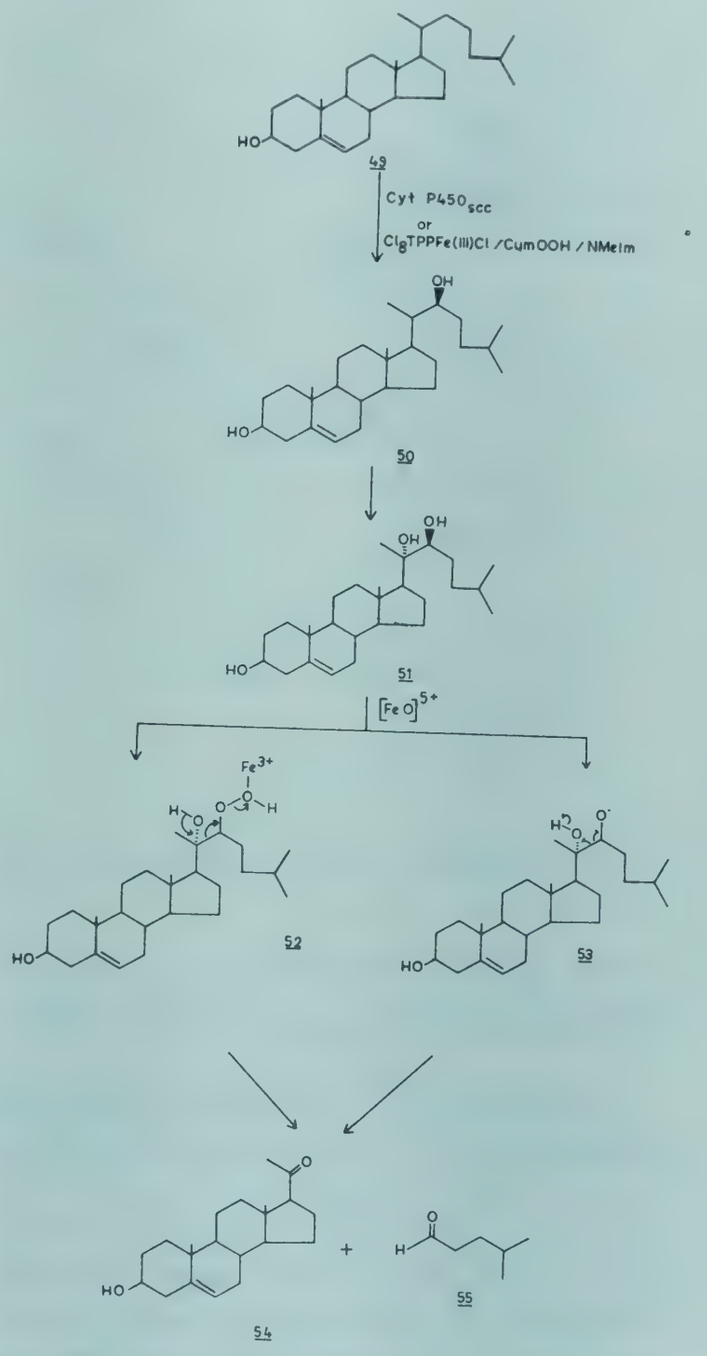
The volatile components of mono- and sesquiterpenoids are used in disinfectant sprays, air freshners, pharmaceutical preparations, scents and flavours. They modify the chemoreceptors in mammals and therefore metabolic studies of volatile mono- and sesquiterpenes by microsomal enzymes in animals have been carried out[48]. The plant cytochrome P450 is involved in the biosynthesis of plant growth regulator gibberellins[49,50] and other diterpenoids.

Oxygenation of Steroids

Multifunctional cytochrome P450 enzymes are involved in the biosynthesis of steroids and catalyze two or three sequential oxidative reactions, each step requiring the consumption of one molecule of oxygen and one molecule of NADPH[51]. The mitocondrial P450scc catalyzes the side chain cleavage of cholesterol (**49**) to pregnenolone (**54**) by two hydroxylations and one cleavage reaction (Scheme 8). Cytochrome P450 catalyzes the formation of 22-hydroxycholesterol (**50**) and 20,22-dihydroxycholesterol (**51**). The cleavage of **51** involves two mechanisms, in the first, the high valent oxoiron radical cation reacts with one of the hydroxyl groups to form peroxide **52** which on proton removal from adjacent hydroxyl group initiates the C-C cleavage



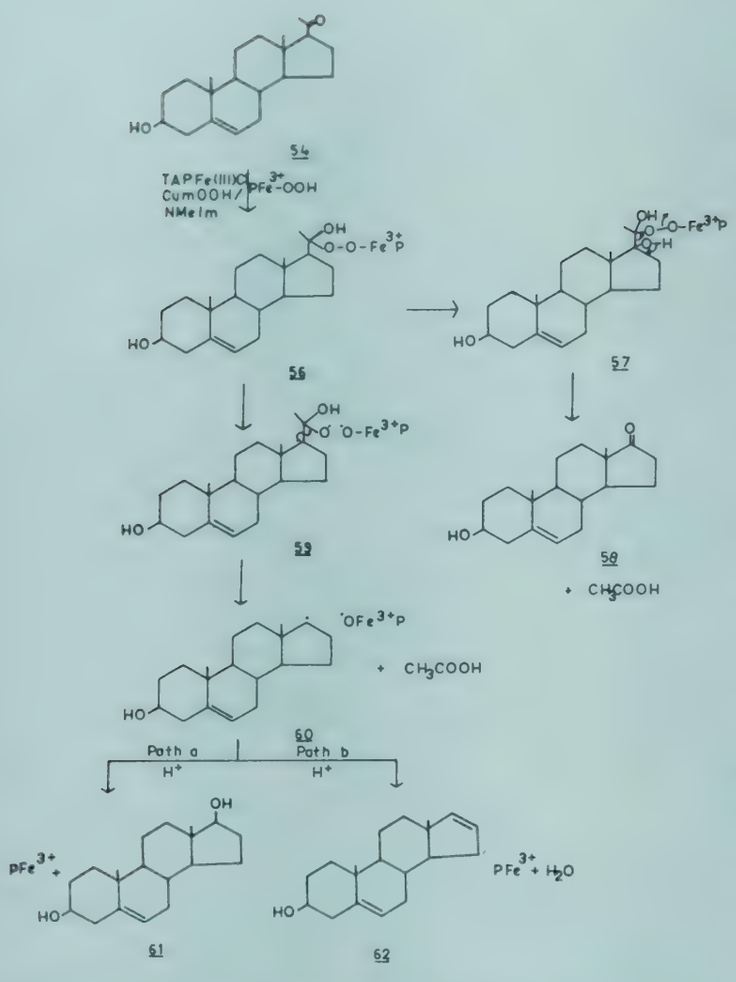
Scheme 7 — Oxidation of geraniol by cytochrome P450 and their chemical model systems



Scheme 8 — Oxidation of cholesterol by cytochrome P450 and their chemical model systems

of intermediate **52** to pregnenolone **54** and **55** (Scheme 8). In the second mechanism, the abstraction of a hydrogen atom from one of the hydroxyl groups by activated oxygen species produces an alkoxyl radical **53** which on homolytic cleavage of the C-C bond followed by a second electron abstraction leads to $[FeOH]^{3+}$ to pregnenolone **54** and product **55** (Scheme 8). The oxidation of cholesterol with H_2O_2 and other monooxygen donors catalyzed by $Cl_8TPPFe(III)Cl$ under different reaction conditions mimicks the side chain cleavage of cholesterol in organic solvents[52] (Scheme 8).

Insect cytochrome P450 has been implicated in the dealkylation of phytosteroids to cholesterol[53-58]. Ecdysone-20-monooxygenase, the insect steroid hydroxylase, is responsible for the conversion of the molting hormone ecdysone to its more physiologically active metabolite 20-hydroxyecdysone[59]. Certain plant flavonoids and other allelochemicals inhibit the insect cytochrome P450 dependent steroid hydroxylase activity in selected insect[52].

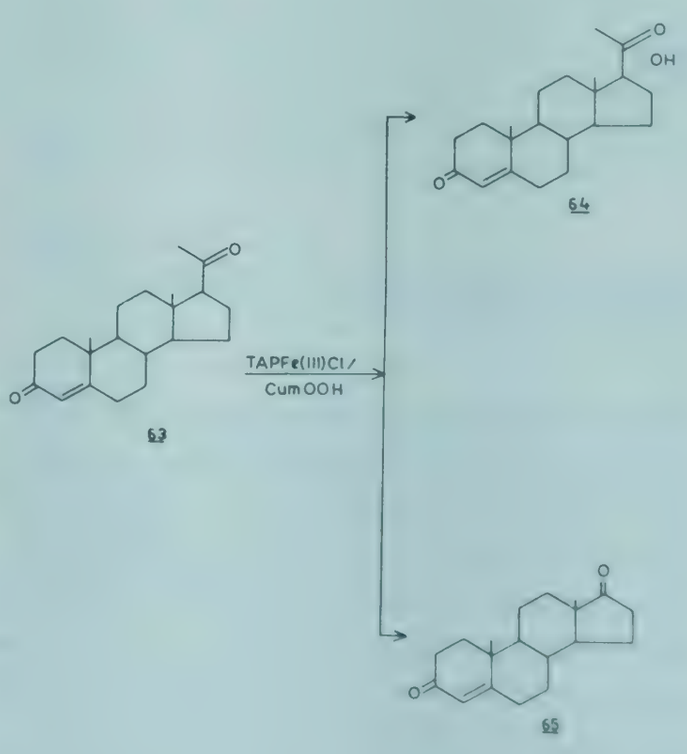


Scheme 9 — The acyl-carbon cleavage of pregnenolone by cytochrome P450 and their model systems

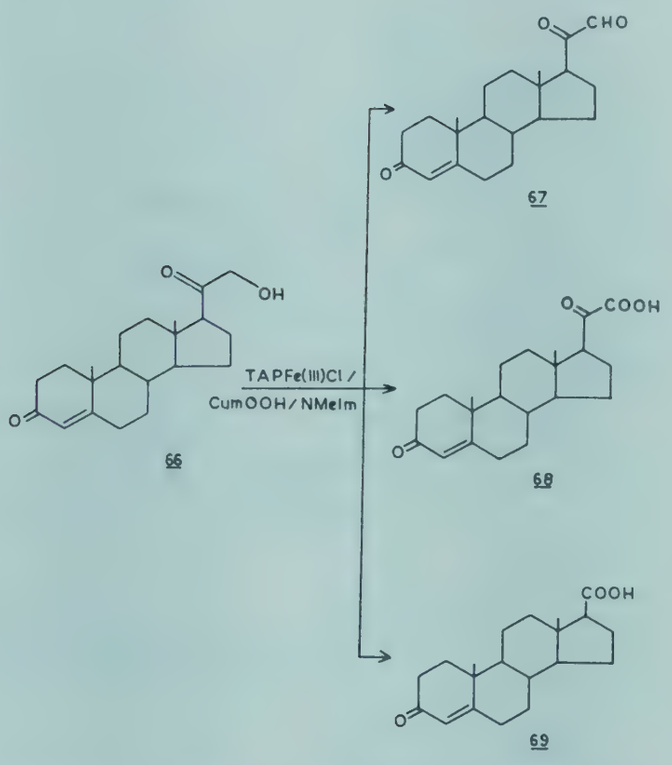
Cytochrome P450 17α catalyzes the acyl-carbon cleavage reaction in the conversion of pregnenolone **54** into 17- keto (**58**), 16-ene (**62**) or 17-OH (**61**) steroid products and acetic acid. The three multifunctional enzymes carry out their catalysis at a single active site but by two distinct activated oxygen species a high valent oxoiron radical cation **7** being involved in the hydroxylation reactions as in the general P450 hydroxylation mechanism, whereas a hydroperoxyintermediate **6** species is involved in the acyl-carbon cleavage. The nucleophilic interaction of hydroperoxyintermediate with electrophilic cabonyl group produces a peroxy adduct **56** which on further hydroxylation and subsequent fragmentation gives the product **58**[57-59] (Scheme 9). The intermediate **56** cleaves homolytically to **59** which on second homolytic cleavage forms **60**. The recombination and elimination in this step lead to the products **61** and **62**, respectively (Scheme 9).

The reaction of progesterone **63** with H_2O_2 and cumene hydroperoxide catalyzed by TAPFe(III)Cl gives 17α- hydroxy-progesterone (**64**), androst-4-en-3,17-dione[47] (**65**) and other products in the absence and presence of N-methylimidazole (NMeIm) in organic solvents (Scheme 10). The Short Catalytic Cycles of cytochrome P450 have been developed by the reaction of cumene hydroperoxide catalysed by TAPFe(III)Cl in the presence or absence of NMeIm in dichloromethane at room temperature and has been used in the oxidation of 21-hydroxypreg-4-en-3,20-dione[48] (**61**) to give 3-oxo-androst-4-en-17-carboxylic acid (**69**), preg-4- en-3,20- dioxo-21-oic acid (**68**) and a non acidic product **67** (Scheme 11).

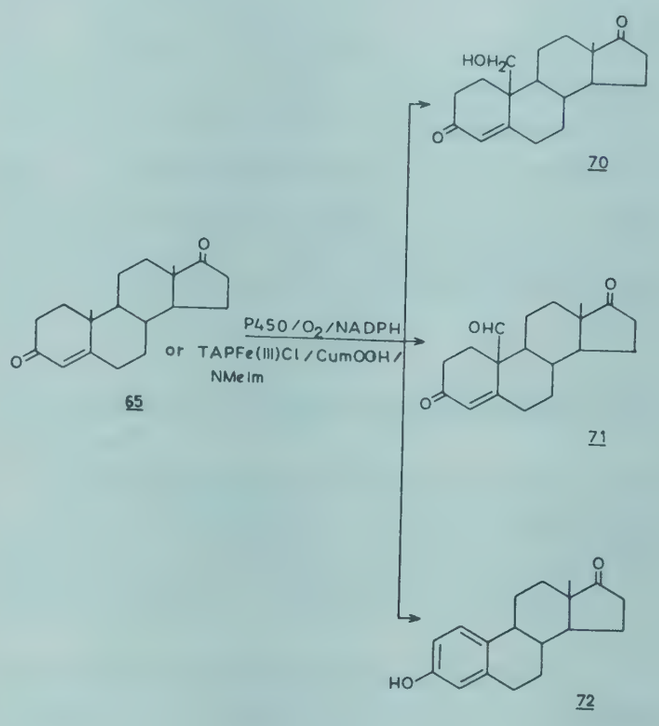
The biotransformation of androgen to estrogen is catalyzed by cytochrome P450 through utilization of three moles each of NADPH and molecular oxygen[62]. The oxidation of androst-4-en-3,17-dione (**65**) with cumene hydroperoxide catalyzed by TAPFe(III)Cl gives 19- hydroxyandrost-4-en-3,17-dione (**70**), androst-4-en-3,17,19- trione (**71**) and estrone (**72**) in the presence and absence of NMeIm at room temprature in organic solvents[63]. The Cl_8TPPFe(III)Cl in the presence of NMeIm is the



Scheme 10 — Oxidation of progesterone with cumene hydroperoxide catalysed by TAPFe(III)Cl



Scheme 11 — Oxidation of 21-hydroxypreg-4-en- 3,20-dione with cumene hydroperoxide catalyzed by TAPFe(III)Cl under different reaction conditions

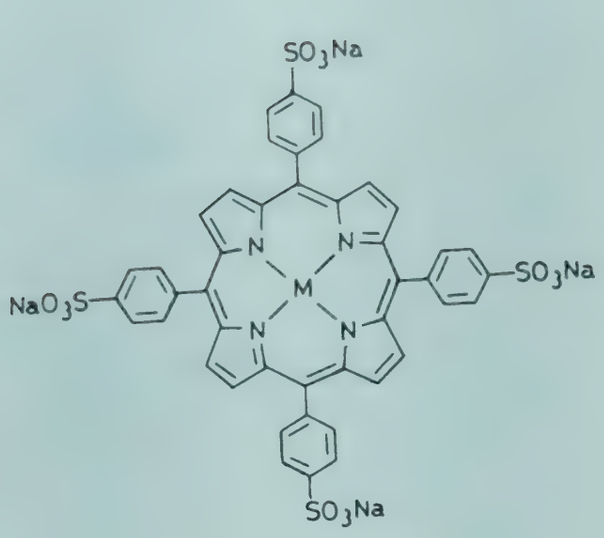


Scheme 12 — Biomimetic oxidation of androst-4- en-3,17-dione

most effective catalytic system for the aromatization of ring A of **65** (Scheme 12).

Aerosol-OT (AOT) reverse micelles are simple and dynamic models for the biological membranes[64,65]. They provide variable microenvironment and reaction media for performing various chemical and enzymatic reactions[66]. Different water soluble anionic and cationic 5,10,15,20-tetraaryl manganese and iron(III) porphyrins have been synthesized (Chart 2) and biomimetic oxidations have been examined in reverse micelles under different conditions. Sulphonation of free base porphyrin is an important method for the preparation of water soluble anionic porphyrins[67,68]. The reaction of water soluble free base porphyrins with Mn(II) salts forms manganese(III)-5,10,15,20- tetra(4′-sulphonatophenyl)porphyrins[69] [TPPMn(III), **73a**], manganese(III)-5,10,15,20- tetra(2′,4′,6′- trimethyl- 3′-sulphonatophenyl)porphyrins [$Me_{12}TPPS_4Mn$(III), **74a**][70], and 5,10,15,20- tetra(2′,6′- dichloro- 3′-sulphonatophenyl)porphyrinato manganese(III)hydrate [Cl_8TPPS_4Mn(III), **75a**][71] in moderate yields (Chart 2). A similar reaction sequence leads to the formation of [$TPPS_4Fe$(III),**73b**][72], [$Me_{12}TPPS_4Fe$(III), **74b**][72] and [Cl_8TPPS_4Fe(III), **75b**][73] in different yields (Chart 2). The symmetrical water soluble cationic manganese(III) (**76a**) and iron(III) (**76b**) have been prepared by the reaction of 5,10,15,20-tetrapyridylporphyrin with alkyl halides followed by metalation (Chart 2). The incorporation of cholesterol in AOT reverse micelles and oxidation with H_2O_2 catalyzed by water soluble $TPPS_4Fe$(III) (**75b**) have been studied under different reaction conditions to give the products **81-86**. The non-aggregating and non μ-oxodimer forming Cl_8TPPS_4Fe(III) (**75b**) is a better catalyst than the simple $TPPS_4Fe$(III) (**73b**) for the production of epoxides (Scheme 13).

The didodecyldimethylammonium bromide and related dialkyl dimethylammonium bromide form vesicles in aqueous solution[75,76]. Different amphiphilic metalloporphyrins (**77-78**) have been prepared by the metalation of amphiphilic porphyrins which, in turn, could be prepared by condensation of two aryl aldehydes with pyrrole and separation of each components by column chromatography[77-80] (Chart 3). The reaction excess of manganese(II) chloride at room temperature with water soluble 5α,10α,15α,20α- tetra (N-methlyisonicotinamidophenyl) porphyrin[81,82] gives 5α,10α,15α,20α-tetra[*o* - (N - methlyisonicotinamidophynyl)porphy-



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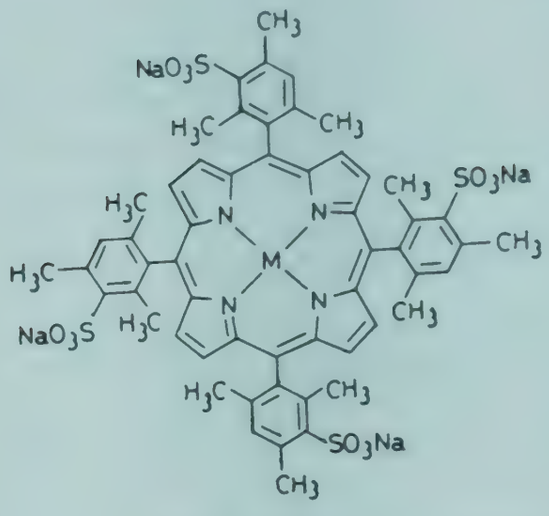

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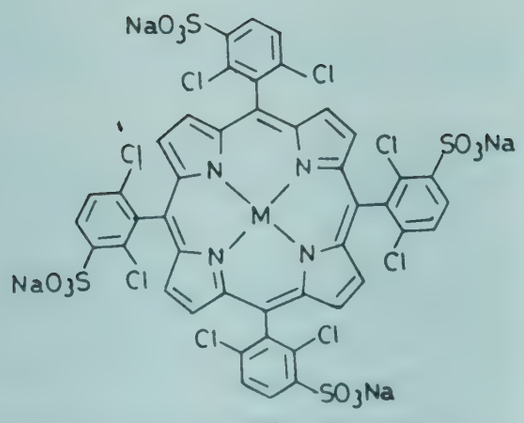

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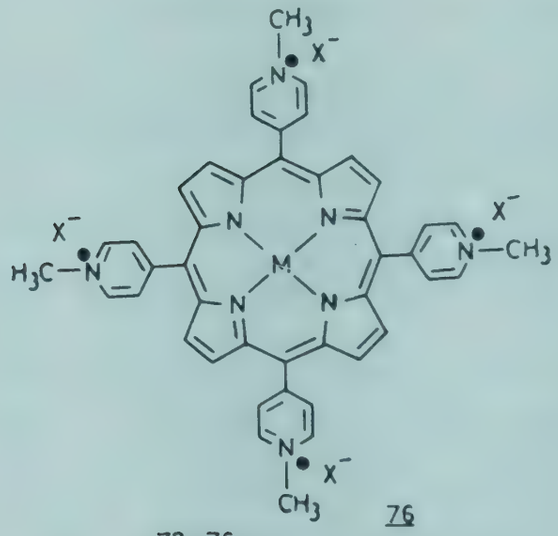

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73-76

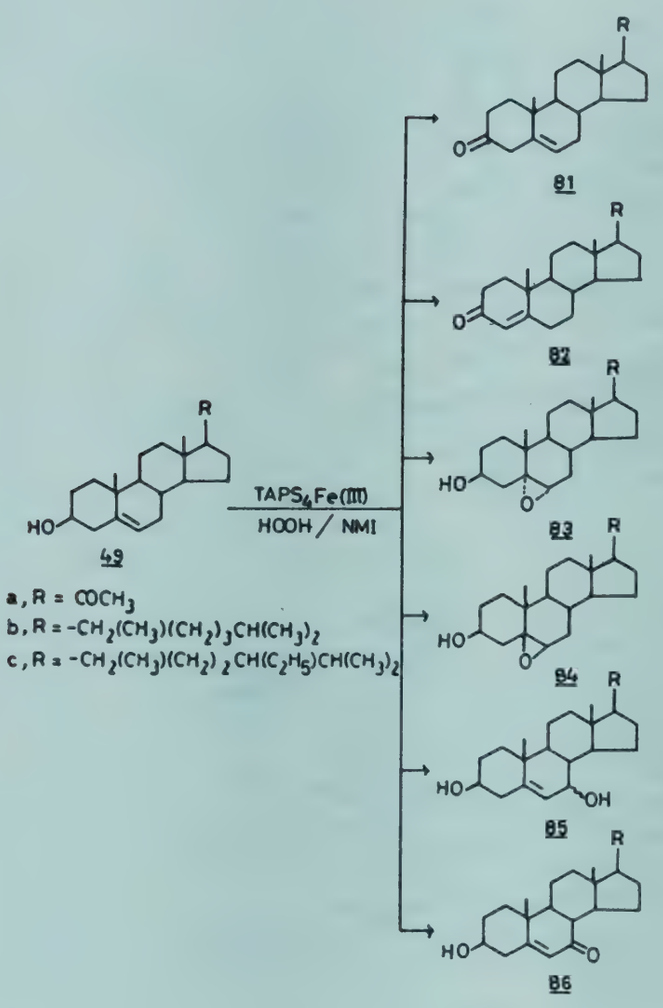
M = 2H
a, M = Mn(III)Cl
b, M = Fe(III)Cl

Chart 2 — Water soluble anionic and cationic tetraaryl Fe(III) and Mn(III)porphyrins

rinatomanganese(III) chloride (**79a**). Similarly, the reaction of 5α,10α,15α,20α- tetra[*o*-aminophenyl]porphyrin and mixed anhydride of 16-hydroxy- hexadecanoic acid gives the corresponding atropisomeric porphyrins and their metal complexes (**80**)[83,84] (Chart 3).

Amphiphilic benzo[g] pteridine has been incorporated into cation vesicles[85]. The cosonication of *cis*-bis(4N-alkylpyridi- niumyl) diphenylporphyrinatomanganese(III) acetate and cholesterol forms the vesicles. It has been found that the oxidation of cholesterol with iodosylbenzene in DDAB vesicles gave higher yields of 5β,6β-epoxide as compared to 5α,6α-epoxy cholesterol[86].

The oxygenation of cholesterol with iodosylbenzene catalyzed by 5α,10α,15α,20α[*o*- (4N-methyl isonicotinamido)phenyl]porphyrinatomanganese(III)



Scheme 13 — Anionic Fe(III)porphyrin catalyzed epoxidation of steroids

acetate gives 5α,6α-epoxides and 5β,6β-epoxides in homogeneous and phospholipid vesicles[87]. The higher yield of 5β,6β-epoxides of above steroids in phospholipid vesicles than homogeneous medium indicates that oxidation is more regioselective in phospholipid vesicles[87]. Regioselectivity in the epoxidation of stigmasterol and other sterols has been observed during the epoxidation of stigmasterol with iodosylbenzene catalyzed by sterol pillared Fe(III) and Mn(III) porphyrin in DMPC vesicles[84]. The oxidation of stigmasterol with iodosylbenzene gives 22,23-epoxy stigmasterol and other products in phospholipid vesicles[84,87].

Oxygenation of Triterpeniods

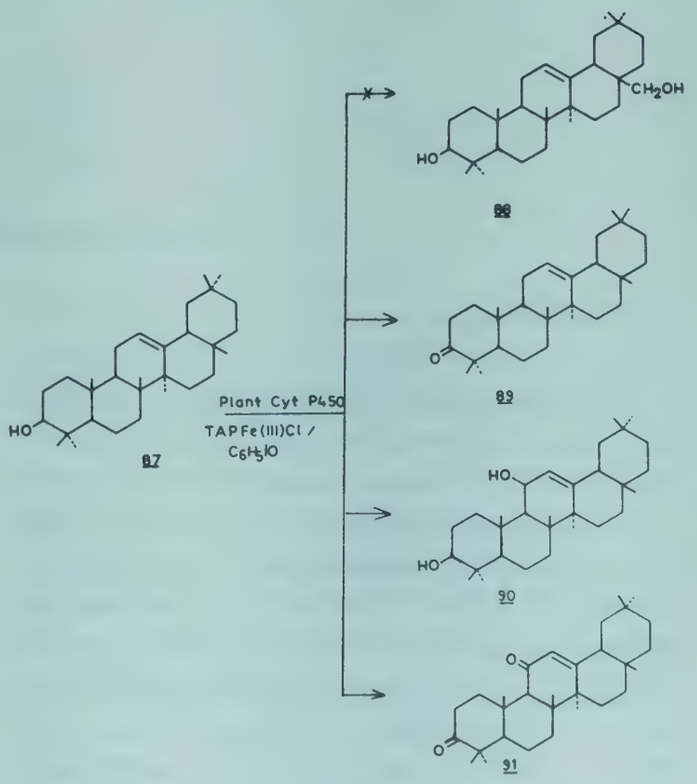
In the triterpene series of 3β-hydroxyolean-12-ene, products oxidised at position 28 are most frequently found in plants, presumably by the action of plant cytochrome P450 by utilization of O_2 and NADPH. Further, 3β-hydroxyolean-12-ene (**87**) and the related oxidation products have been isolated from the primary food plants of tasar silk worm *Antheraea mylitta* [88]. The oxidation of **87** with iodosylbenzene catalyzed in dichloromethane does not give the compound **88** with alcoholic group at 28 position; instead β-amyrenone (**89**), 3β,11α- dihydroxyolean-12-ene (**90**) and 3,11-dione-olean-12-ene (**91**) are formed in moderate yields[89] (Scheme 14).

Biosynthesis and Oxygenation of Nitrogen Heterocycles

Cytochrome P450, hepatic flavoenzyme[90], amine oxidase[91] and related enzymes are involved in the oxygenation and oxidation of alkaloids, nitrogen heterocycles and related nitrogen compounds[92].

Biosynthesis and Oxygenation of Alkaloids

Alkaloids are important secondary metabolites produced by plants and animals. They constitute a diverse group of nitrogen heterocycles or nitrogen containing compounds. Important aminoacids are precursors for the biosynthesis of different alkaloids.



Scheme 14 — Oxidation of 3β- hydroxyolean-12-ene with chemical model systems

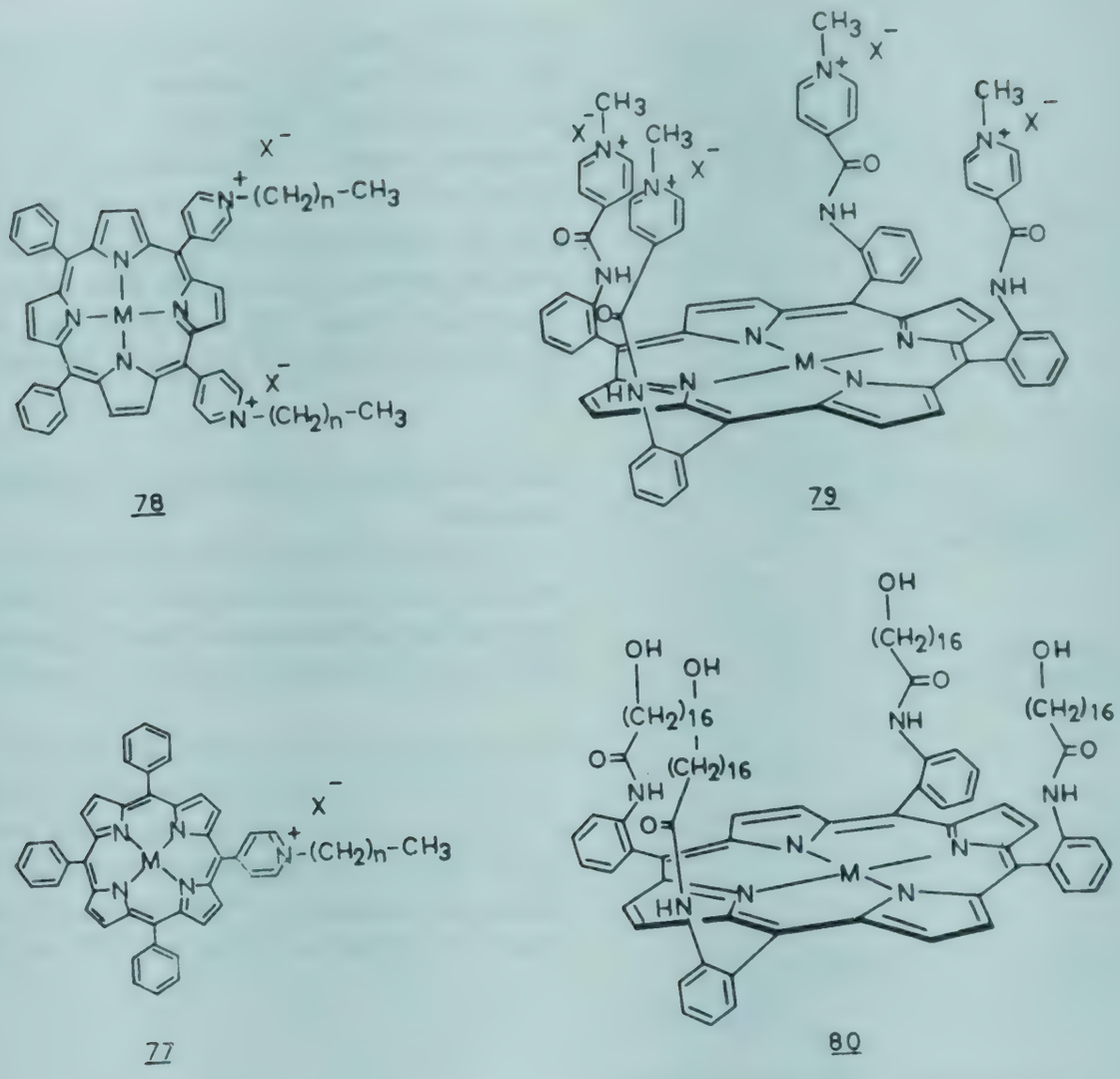
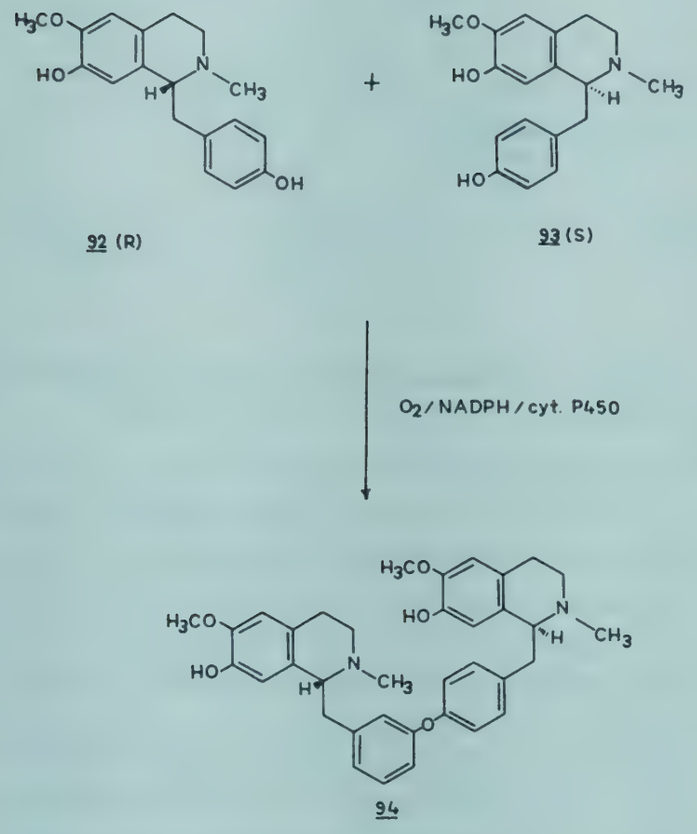


Chart 3 — Selected Fe(III) and Mn(III) atropisomeric porphyrins

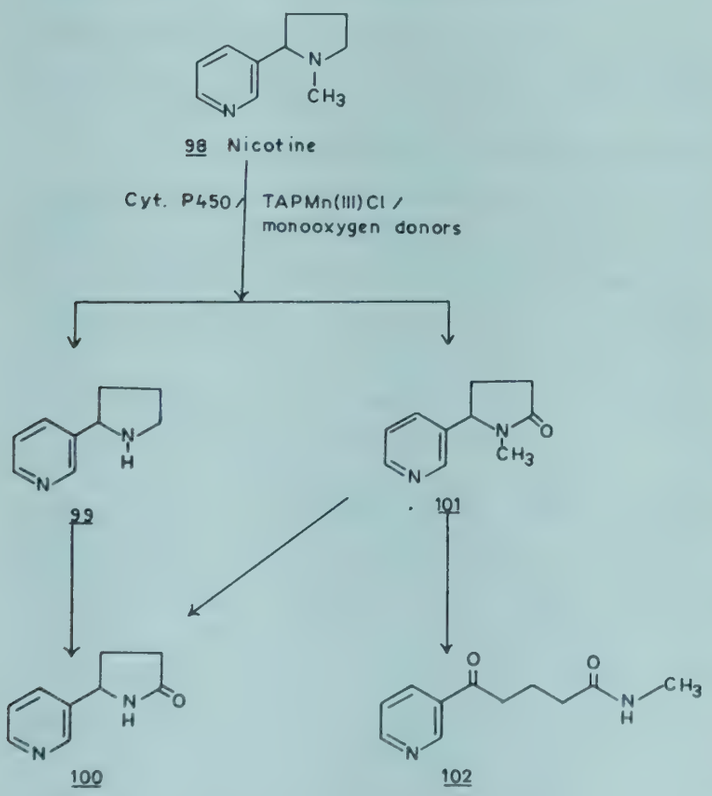
The oxidative phenol coupling of (R)-(92) and (S)-mecoclaurine (93) catalyzed by cytochrome P450 leads to benzyltetrahydroisoquinoline alkaloid (94) in alkaloid biosysthesis in plant cell culture[93] (Scheme 15). Intramolecular oxidative C-C phenol coupling of (R)-reticutine (95) forms the biradical (96) and combines to salutaridine (97) is catalyzed by plant cytochrome P450 in the biosynthesis of morphine alkaloid[94] (Scheme 16). Oxidative phenol coupling of reticuline to salutaridine with potassium ferricyanide[95] and lead tetraacetate[96] has been achieved. The monooxygen donor NaOCl and TPPMn(III)Cl have been used in the oxidative phenol coupling of benzyl isoquinoline alkaloids[97]. Nicotine (98) is metabolised to nornicotine (99), norcotinine (100) and cotinine (101). The formation of norcotinine occurs either through cotinine or nornicotine. The oxidation of nicotine with iodosylbenzene catalyzed by manganese(III) porphyrin gives these as well as open chain product (102)[99] (Scheme 17). Plant cytochromes P450 are involved in the biosynthesis of different alkaloids[100,101].

Oxygenation of Nitrogen Heterocycles

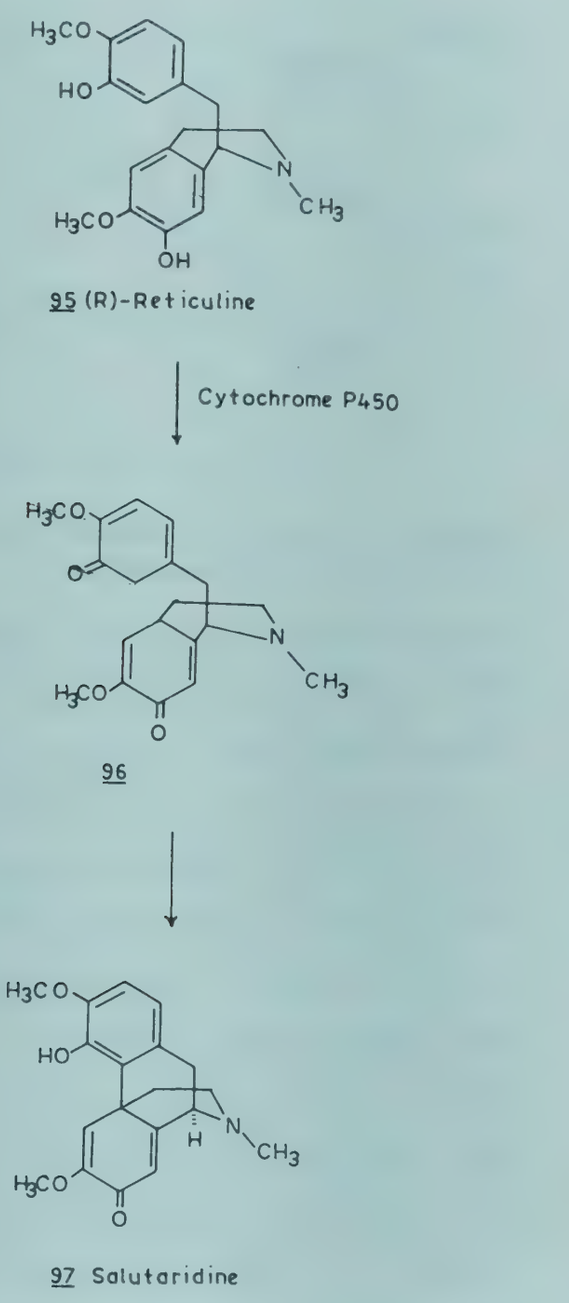
Cytochrome P450 has been found to catalyze the oxygenation and oxidation of biologically active nitrogen heterocycles. Several of dihydropyridines are important biologically active compounds. The meta-



Scheme 15 — Cytochrome P450 catalyzed oxidative phenol coupling of R- and S-macoclaurine



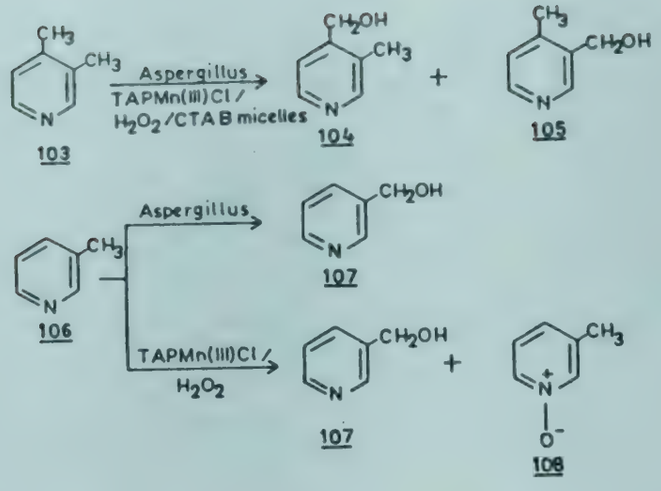
Scheme 17 — Oxidation of nicotine catalyzed by cytochrome P450 and their chemical model



Scheme 16 — Intramolecular oxidative phenol coupling of (R)- reticuline catalyzed by cytochrome P450

bolisms ot these compounds have been examined by cytochrome P450 and their model systems[102].

The compound 3,4-dimethylpyridine **(103)** is hydroxylated to 3- hydroxy-methyl-4-methylpyridine **(105)** and 4-hydroxymethyl-3- methylpyridine **(104)** catalyzed by microbial cytochrome P450 from *Aspergillus* in 59% and 40% yields, respectively. The preferential oxidation of carbon 3-methyl group of pyridine is noteworthy. This regioselective C-oxidation over N-oxidation has been mimicked successfully by using metalloporphyrins and monooxygen



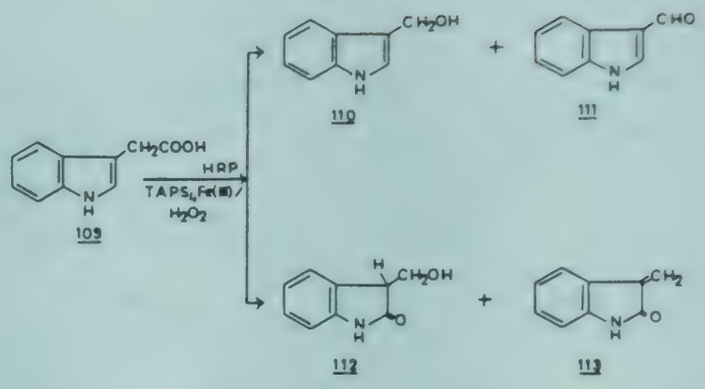
Scheme 18 — Oxidation of 3,4-dimethylpyridine catalyzed by cytochrome P450 and their model system

donors in aqueous CTAB micelles. Similarly, oxidation of 3-methylpyridine (**106**) gives the corresponding 3- hydroxymethylpyridine (**107**), whereas the chemical model system gives **107** as a minor and **108** as a major oxidation product[103](Scheme 18). The structure, geometry and availability of lone pair of nitrogen govern the oxidation of nitrogen or carbon atom of the alkaloids and nitrogen heterocycles[104].

Plant hormone indole-3-acetic acid (IAA, **109**) is oxidised by plant peroxidase to indole-3-carbinol (**110**), indole-3- caboxaldehyde (**111**), oxindole-3-methanol (**112**) and methylene oxindole (**113**) in different plants. The oxidation of IAA with H_2O_2 catalyzed by Horse Radish Peroxidase has been studied under diffferent reaction conditions to understand the molecular mechanism of the metabolites of IAA in plants[105]. The decarboxylation and subsequent oxidation of **109** with H_2O_2 catalyzed by water soluble iron(III)porphyrin (**75b**) in reverse micelles has been studied and changes in oxidation products have been observed in cationic rather than anionic reverse micelles[106] (Scheme 19).

The oxidation of 1,3-dimethyluracil and 1,3-dimethyl-thymine with monooxygen donors catalyzed by mangenese(III) porphyrins has been studied to understand the oxidation of pyrimidine base of RNA and DNA as well as the site specific cleavage of DNA.

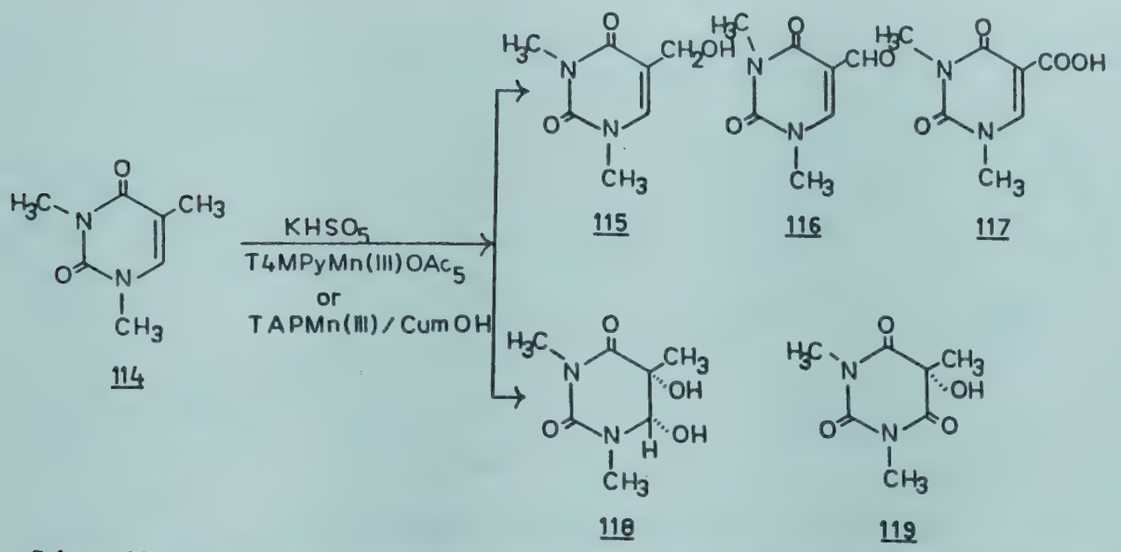
The oxygenation of 1,3-dimethyluracil with cumene hydroperoxide catalyzed by different TAPMn(III)Cl gives 5-hydroxy-1,3- dimethyluracil



Scheme 19 — Oxidation of indole-3-acetic acid with HRP and their chemical model system in AOT reverse micelles

as the main product[107]. Thymine is more susceptible to oxidative modifications as compared to other bases of nucleic acids. The oxidation of 1,3-dimethyl-thymine (**114**) with cumene hydroperoxide catalyzed by TAPMn(III)Cl gives 5- hydroxymethyl-1,3 - dimethyluracil (**115**), 5- formyl-1,3-dimethyl- uracil (**116**) and 5 - carboxy-1,3-dimethyluracil (**117**) in dichloromethane[108] (Scheme 20). The oxygenation of **114** with oxone catalyzed by 5,10,15,20-tetrakis(4N- methylpyridiniumyl)porphyrinatomanganese(III)pentaacetate in phosphste buffer gives side chain oxidation products as above along with *cis*-1,3-dimethylthymine-5,6-glycol (**118**) and 1,3,5- trimethyl-5-hydroxybarbituricacid (**119**) in different yields depending upon the *p*H of the reaction media[109] (Scheme 20). The oxidation of AMP with $KHSO_5$ catalyzed by **74a** gives 8- hydroxyadenosin-5′-monophosphate[110].

Cationic water soluble 5,10,15,20-tetraarylporphyrins interact with DNA[111,112], and the corresponding manganese derivatives in the presence of water soluble monooxygen donors, are efficient catalytic systems for the cleavage of DNA[113]. The use of chemical nucleases in molecular biology is increasing as compared to that of enzymatic nucleases[114,115]. The iron(III) and manganese(III)- 5,10,15,20-tetrakis(4-N-methylpyridiniumyl) porphyrins bind with minor groove of DNA with specific preference for A-T sequence of DNA base pairs. The oxo-iron or oxo-manganese porphyrin complexes are formed by the reaction of either molecular oxygen in the presence of a reducing agent or monooxygen donors with transition metal complexes of porphyrins. The high valent oxo-metal complexes abstract hydrogen atom from the sugar and thus are responsible for the



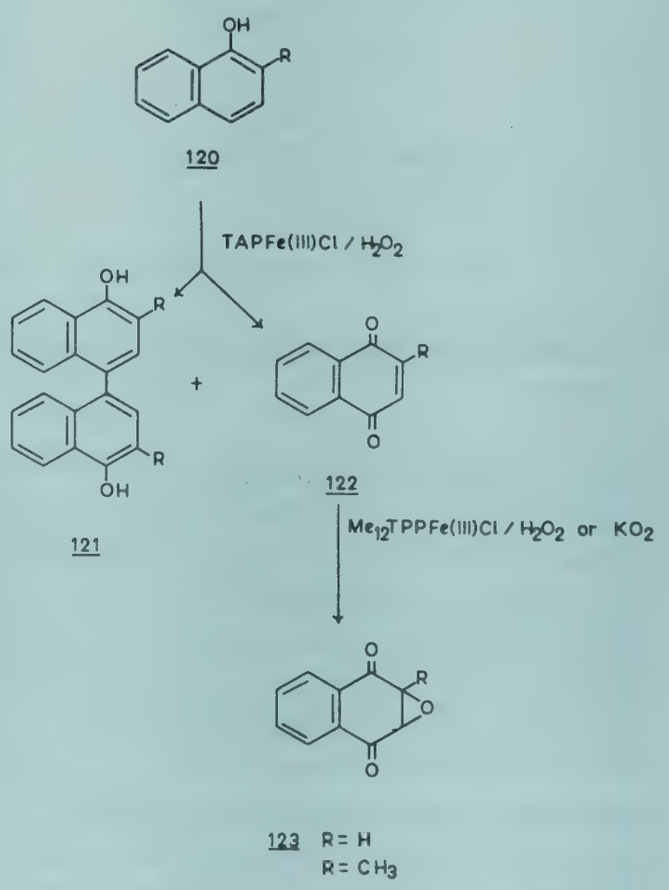
Scheme 20 — Oxidation of thymine with different monooxygen donors and Mn(III)porphyrins

base removal, leading to the formation of 5-methylene-2-furanone(5-MF). The reaction takes place at position 4′ to give a base and α, β- unsaturated compounds. The hydroxylation at position 5′ is responsible for the formation of furfural (FUR) and other products. The oxidation at C-H of C-1 by a oxometalloporphyrin differs from the DNA cleavage by iron- bleomycin[115-117]. Different covalently linked porphyrin complexes have been synthesized and used as chemical nucleases in molecular biology[118].

Oxygenation of Phenolics and Related Compounds

Phenolics are aromatic compounds with hydroxy group directly attached to aromatic rings and have been classified into monohydric, dihydric and trihydric, depending upon the presence of one, two and three hydroxy group attached to aromatic rings. They are important secondary metabolites and are involved in fruit browning, wine or juice processing, pulp delignification and many other chemical and enzymatic processes[119,120]. Plant phenolics are involved in plant-herbivore interactions[121] and other biochemical processes[122,123].

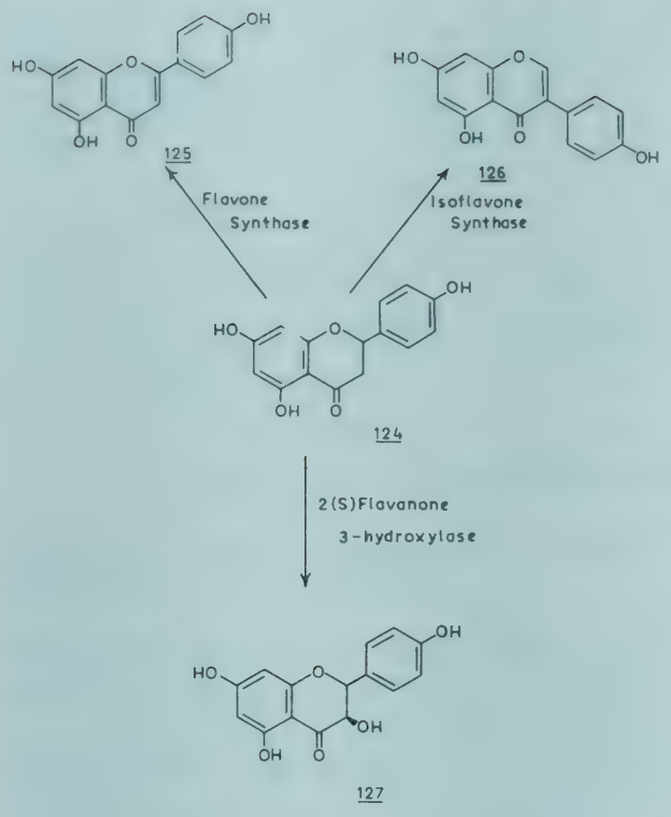
Oxidation of selected phenols (**120**) with H_2O_2 catalyzed by electron donating and electron withdrawing group in the aryl ring of TAPFe(III)Cl give oxidative coupled products **121** and quinones **122** under various reaction conditions[124] (Scheme 21). The oxidation of electron deficient quinones (**122**) with H_2O_2 and potassium superoxide catalyzed by electron rich metalloporphyrins, produces the corresponding quinone epoxides (**123**) (Scheme 21). The



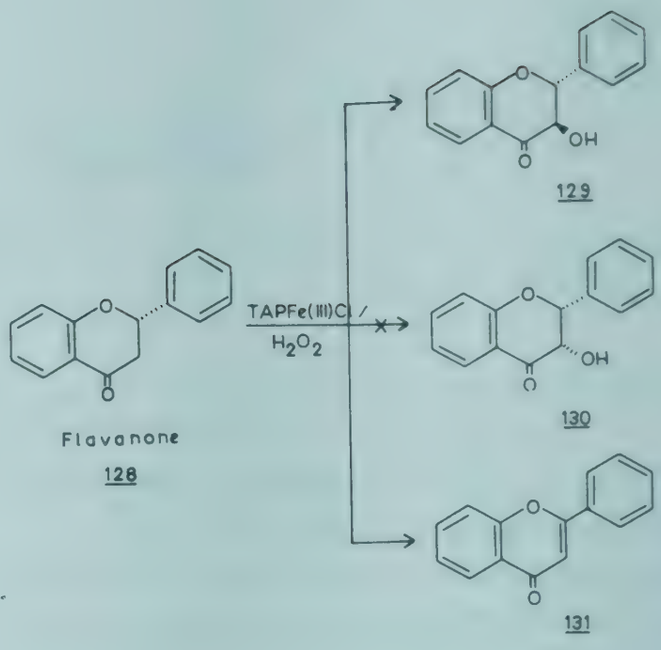
Scheme 21 — Oxygenation and oxidation of selected phenols by chemical model systems

reactions of simple phenols with monooxygen donors catalyzed by different iron(III) porphyrins also give quinones and oxidative coupled products as reported by some researchers[125-128].

The flavanone is the branching point for the synthesis of different flavanoids. Flavanone **124** is converted into isoflavanone **126** by isoflavanone synthase, an isoenzyme of cytochrome P450 by util-



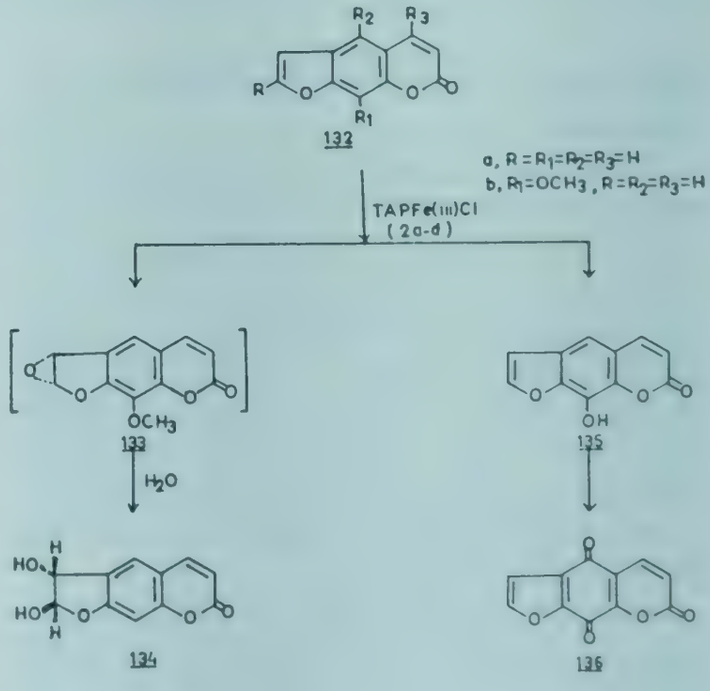
Scheme 22 — Biosynthesis of different flavanoids from flavanone



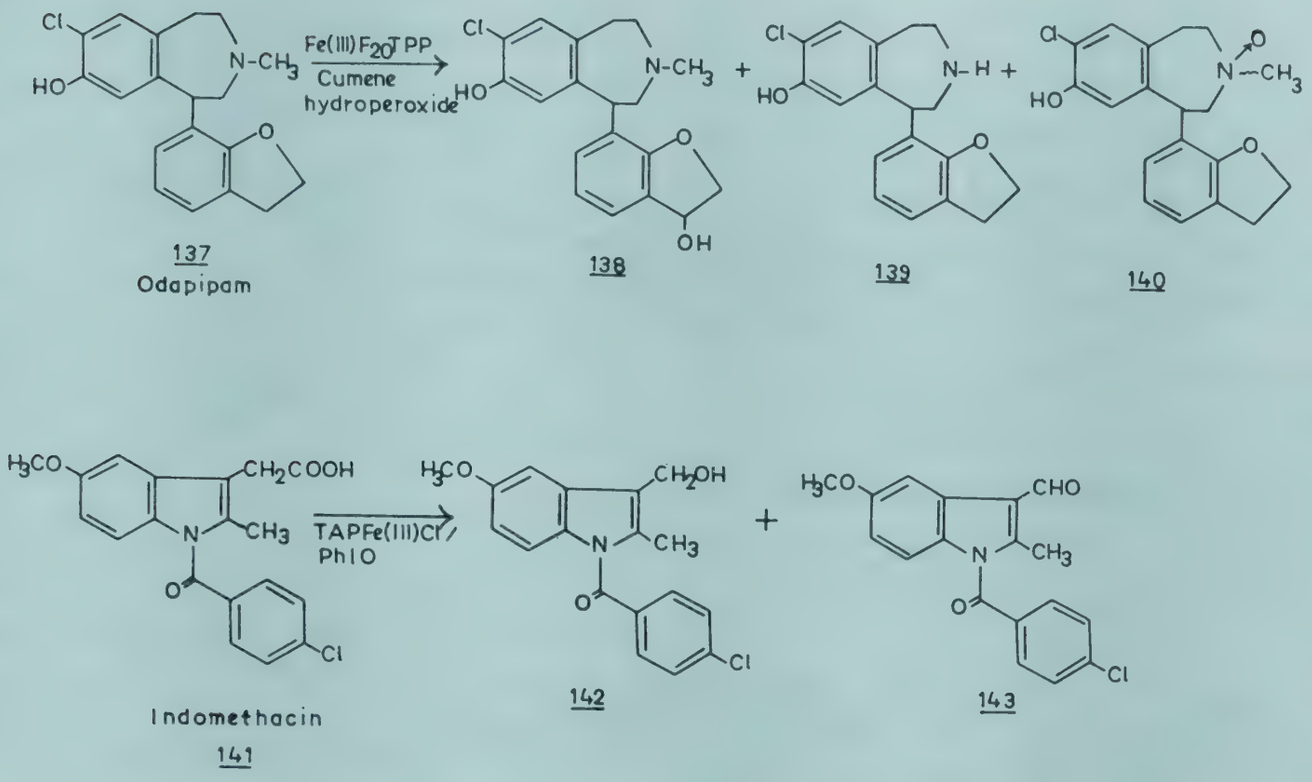
Scheme 23 — Biomimetic oxidation of flavanone by chemical model of cytochrome P450

izing of NADPH and molecular oxygen[129]. The flavanone is converted into flavone **125** by flavanone synthase[130] and 3-hydroxyflavanone (**127**) is formed by the reaction of 2-oxoglutarate monooxygenase or cytochrome P450 monooxygenase[131] by utilizing NADPH and molecular oxygen (Scheme 22). In order to mimick these reactions the oxidation of simple flavanones (**128**) with H_2O_2 and other monooxygen donors catalyzed by TAPFe(III)Cl, gives *trans*-3-hydroxyflavanone (**129**), *cis*-3- hydroxyflavanone (**130**), flavone **131** as the major products with some minor products in micellar media[132] (Scheme 23).

Psoralen, 8-methoxypsoralen, 5-methoxypsoralen and 4,5′,8- trimethoxypsoralen are effective agents in photochemotherapy and are extensively metabolized by hepatic cytochrome P450 monooxygenase systems[133]. The reaction of different 8-methoxypsoralens (**132**) with monooxygen donors catalyzed by TAPFe(III)Cl gives different metabolites of psoralens, i.e., 6,7-epoxy-8-methoxypsoralen (**133**), 6,7-dihydroxy-8-methoxypsoralen (**134**), 8-hydroxypsoralen (**135**) and 5,8-dioxopsoralen (**136**)[134] (Scheme 24).



Scheme 24 — Oxidation of psoralens and 8- methoxypsoralen with cytochrome P450 and their model system



Scheme 25 — Oxygenation of odapipam and indomethacin with chemical models of cytochrome P450

Detoxification and Metabolism of Xenobiotics

Detoxification of xenobiotics is a major function of the range of cytochromes P450 in animals and plants[135,136]. Metabolic activation is the first step in the biological response of xenobiotics in the organism. The resulting metabolites of xenobiotics induce the pharmacological response of the drugs or carcinogenic effect of carcinogens.

Drugs

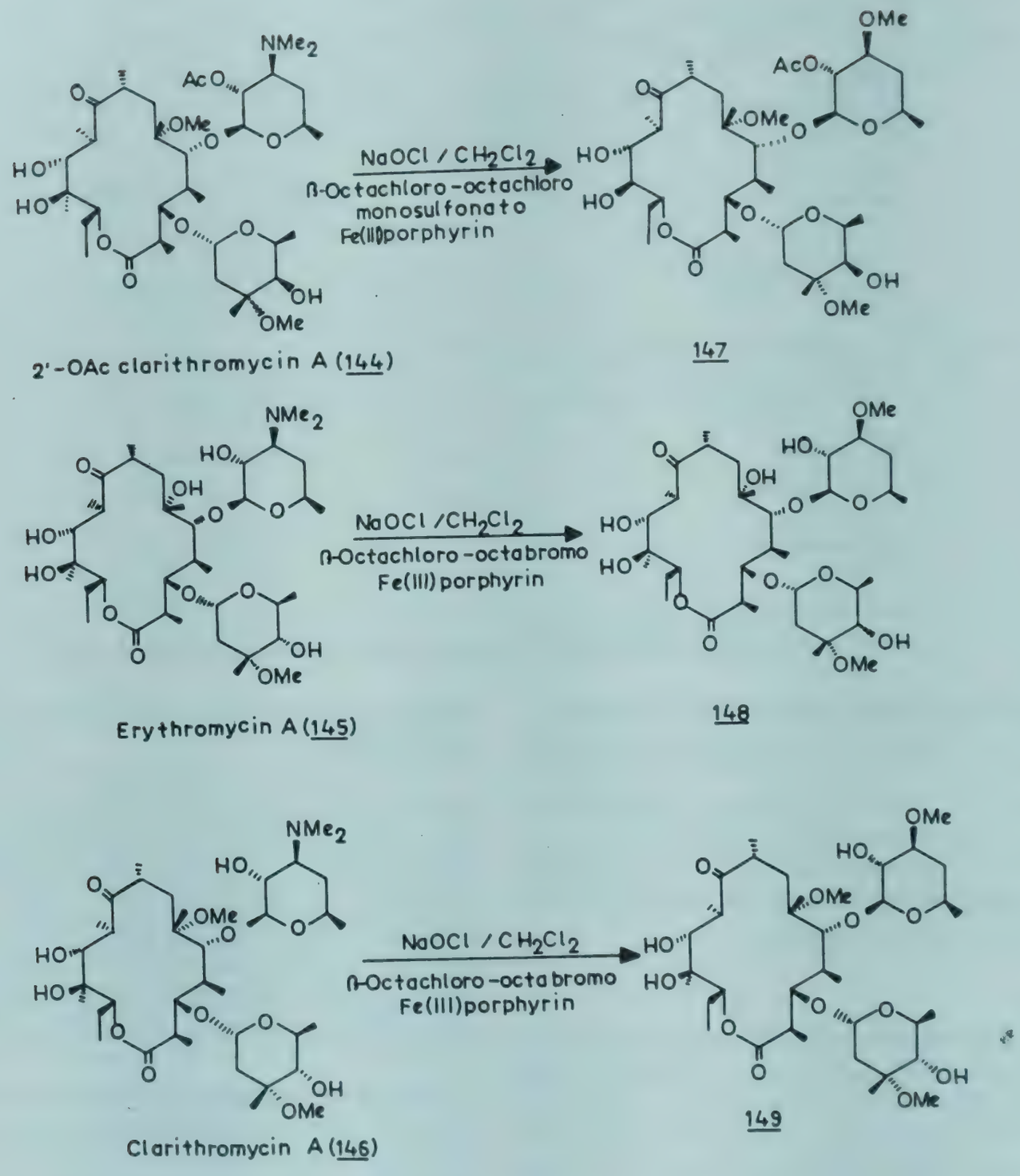
The bioactivation of drugs has been studied with perfused organs, isolated intact cells, tissue homogenate and isolated purified enzymes. Isolated and purified enzymes are more suitable to study the biotransformation of different drugs at molecular level. Since cytochromes P450 and peroxidases contain an iron(III)protoporphyrin IX as a prosthetic group, many attempts have been made to mimick their oxygenase or oxidase activities with synthetic metalloporphyrins and different monooxygen donors.

Different chemical models for cytochromes P450 and other monooxygenases have been developed and used for the oxidation of various drugs[137-139]. Water soluble metalloporphyrin and monooxygen donors oxidise the anticancer drug ellipticine derivatives to quinone-imine[140].

The oxygenation of odapipam[141] **(137)** with F_{20}TPPFe(III)Cl and cumenehydroperoxide gives a benzyl hydroxylated product **(138)**, demethylated product **139** and N-oxide **140** in different yields. The oxidation of indomethacin[142] **(141)** with TAPFe(III)Cl/PhIO gives one carbon reduced N-(4-chlorobenzoyl)-3-hydroxymethyl-5- methoxyindole **(142)** and N-(4-chlorobenzoyl)-3-formyl-5-methoxyindole**(143)**in moderate yields (Scheme 25).

Reaction of erythromycin and other microlides **(144-146)** with halogenated metalloporphyrin and monooxygen donor systems form corresponding methoxyderivatives with retention of configuration[143] **(147-149)** (Scheme 26). The involvement of high valent oxoiron intermediate has been implicated in the molecular mechanism of antimalarial artemisinin and its analogs[144,145].

Electron rich nitrogen and sulphur containing drugs are oxidised by flavin monooxygenases[146] where 4α-hydroperoxy flavin intermediate transfers monooxygen to substrate. Selected chemical model systems for natural flavin monooxygenases have



Scheme 26 — Reaction of erythromycin and other microlides with halogenated metalloporphyrin and monooxygen donor

been used in the oxidation of nitrogen containing compounds under different reaction conditions[147,148].

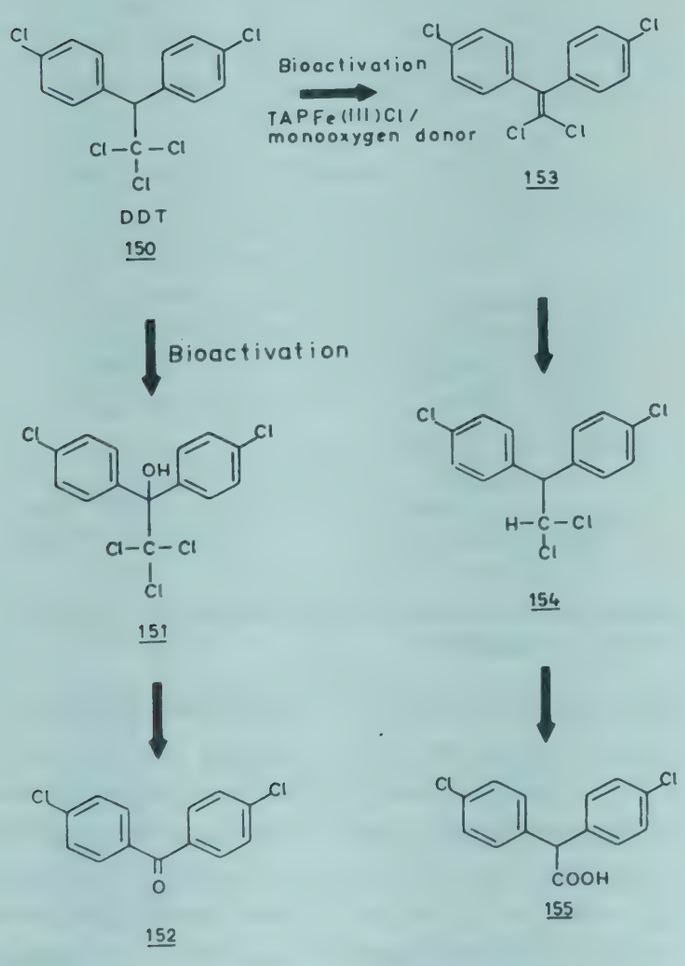
Chemical model systems have been used in short and efficient synthesis of drug intermediates, synthesis of large amount of drug metabolites for pharmacological testing and isolation of unstable metabolites in milder and controlled conditions.

Pesticides

Pesticides, used to prevent diseases and increase production of food and fibres, may be classified as insecticides, pheremones, antifeedants and repel-

lants[149]. Plant pesticides are metabolized in plants by a variety of cytochrome P450 and other monooxygenases. The N-demethylation of antipyretic drug aminopyrine and herbicide[150] chloroturon has been observed by cytochrome P450 in *Jerusalem artichoke*[151]. The ethoxy coumarin and ethoxy resourfin are O-de-ethylated by two different plant cytochromes from *J. artichokes*[152]. Different pesticides have been hydroxylated and heteroatom oxygenations have been reported by plant cytochrome P450[153]. Plant cytochromes P450 are of great commercial significance as herbicide resistant as well as in eco- toxicology.

Polychlorinated pesticide, dichlorodiphenyltrichloroethane (DDT) (**150**) is recalcitrant to biotransformation and is biomagnified and accumulated in plant and animal tissues[154]. DDT in insects is metabolized to 1,1-dichloro-2,2-bis(*p*-chlorophenyl)ethylene (**153**), bis-(*p*-chlorophenyl)acetic acid (**155**) and other minor products (**151,152,154**).



Scheme 27 — Oxidation of DDT with cytochrome P450 and their chemical model system

DDT is partially metabolized by chemical model systems to give these products[155] (Scheme 27).

Chlorinated polycyclodiene insecticides are highly lipid soluble and are activated and biodegraded with mixed function oxidase to the corresponding epoxy and halocarbonyl compounds[156,157]. The epoxidation and dechlorination of selected polycyclodienes have been mimicked by chemical model systems.

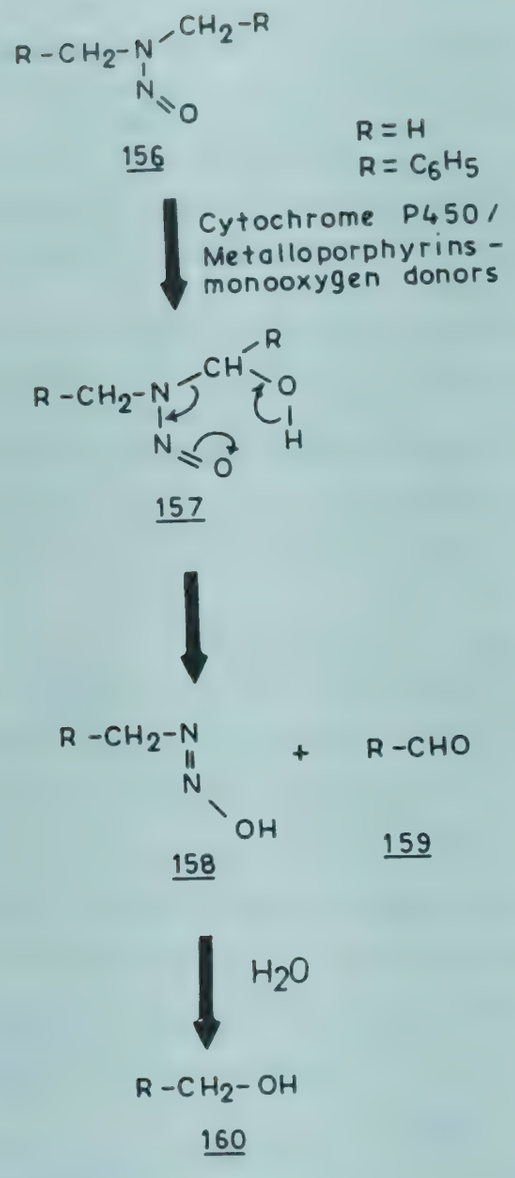
Organophosphates are important classes of insecticides and are metabolized to the corresponding oxygenated compounds by different monooxygenases. The oxidative desulphurisation of pentavalent phosphorous derivatives is catalyzed by manganese porphyrins with periodate or iodosylbenzene as oxidants[158,159].

Carcinogens and Pollutants

Cytochromes P450 have been found to be involved in the bioactivation of carcinogens and pollutants. The N- nitrosodialkylamines (**156**) are potent procarcinogens[160]. The enzymatic α-hydroxylation by cytochrome P450 and other oxidative enzymes is the initial step in the biotransformation of **156** to the ultimate carcinogens[161]. The α-hydroxylation of **156** to α- hydroxynitrosamine (**157**) has been mimicked by chemical models for short and long catalytic cycles of cytochrome P450 in organic[162] and organised media[163] (Scheme 28).

Polyaromatic hydrocarbons are the potent carcinogens. They are metabolized by cytochromes P450[164]. The chemical models for cytochromes P450 mimick oxygenation reactions of polyaromatic hydrocarbons. Fullerenes have many six and five membered rings in their structures and are regarded as the derivatives of polyaromatic hydrocarbons. Reaction of [60]fullerene (**161**) with cytochrome P450 model systems gives 1,2-epoxy[60]fullerene (**162**), 1,2,3,4-diepoxyfullerene (**163**) and 1,2,3,4,9,10- triepoxy[60]fullerene (**164**) and 1,2,3,4,11,12-triepoxy[60]fullerene (**165**)[165] (Scheme 29).

Oxidative degradation of aromatic pollutant, 2,4,6- trichlorophenol by chemical models of lignases using metalloporphyrins and monooxygen donors has been achieved under different reaction conditions[166,167]. The pollutant nitrite ion has been activated by iron(III)porphyrins and used as



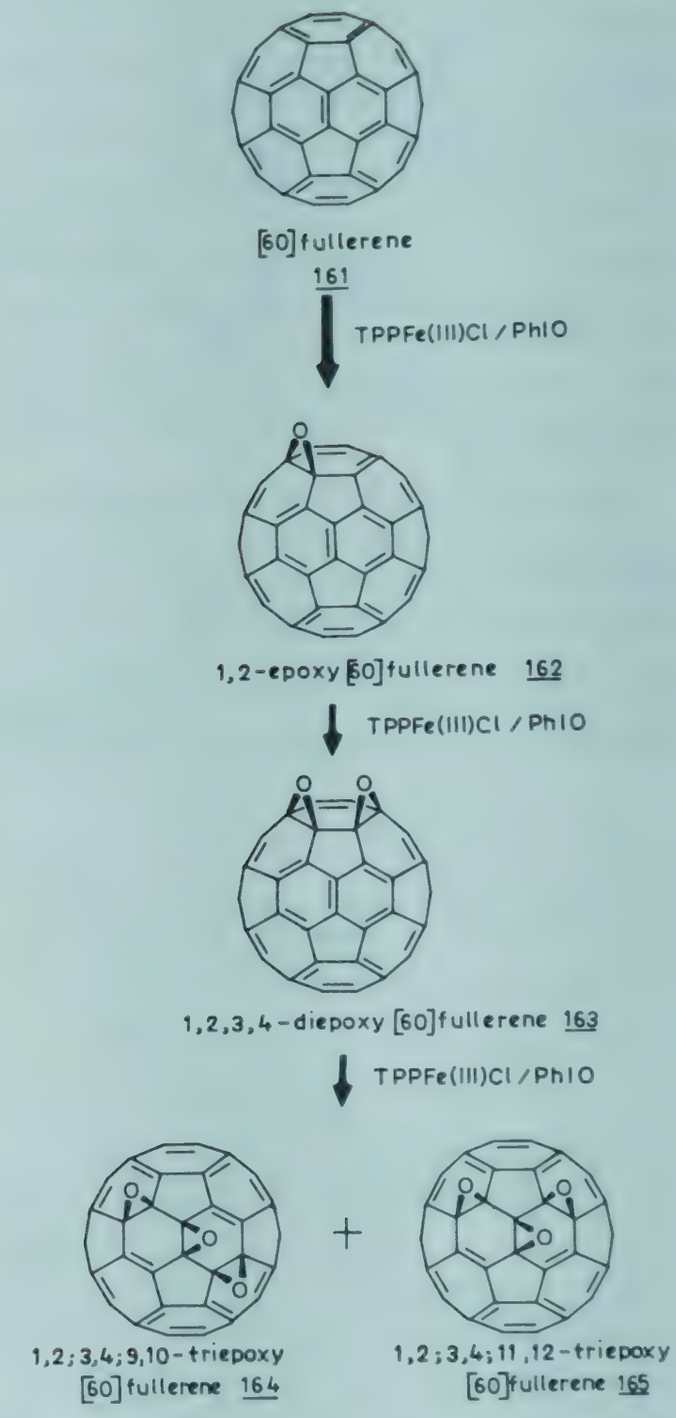
Scheme 28 — Oxygenation of N- nitrosodialkylamines by chemical models for cytochrome P450

stoichiometric oxygen transfer to carbon, nitrogen, phosphorous and sulphur compounds[168,169].

Conclusion

Although a large amount of physicochemical data has been collected over the years about protein engineering for designing cytochromes P450 for modulated substrate specificity or increased hydroxylation efficiency, ultimate use of protein engineering still remains to be a subject of research[170-172].

The chemical models for cytochrome P450, flavin monooxygenases and pteridine monooxygenases are more suitable for the development of frontier technology for chemical industry. The development of



Scheme 29 — Oxygenation of [60]fullerene with cytochrome P450 chemical models

homogeneous catalysts for hydroxylation, epoxidation and other reactions in organic synthesis using above chemical model systems is an important area in environmentally benign organic synthesis of fine chemicals[173,174]. The water soluble metalloporphyrins on solid supports may be used in the development of heterogeneous catalysts[175] in cleaner synthesis. Chemical model systems are also used in the site specific cleavage of DNA and other biochemical reactions in molecular biology. Chemical

model systems are being advanced to replace the test animals for metabolic study.

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Membrane Technology With Special Reference to Filtration and Reverse Osmosis

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Membrane based separation technology (MBST) is a selective permeation technology which is practicable and economically attractive. It refers to pressure driven separation of components of a fluid mixture by selective permeation of the permeate (solvent with smaller molecule size) from the retentate (solute with larger molecule size) through a semipermeable membrane. The present paper describes various membrane operation techniques with special reference to Ultra Filtration (UF) and reverse osmosis (RO). Their vast applications in Industry are also discussed.

Introduction

Historically, the processes of membrane technology have been defined by various scientists and technologists in different ways which have been revised and described in depth during the later part of 20th century.

Membrane technology is a process whereby a solution containing a solute of molecular size significantly greater than that of the solvent is depleted of the solvent by the application of a hydraulic pressure which forces only the solvent to flow through a suitable semipermeable membrane. A semipermeable membrane may be natural or synthetic which allows selective transport of one particular component in preference to others. There are mainly six membrane separation processes, as shown in Table 1.

Table 1 shows that Ultra Filtration (UF), Reverse Osmosis (RO) and Micro Filtration (MF) are pressure driven techniques and the basic difference among them is the application of hydraulic pressure to speed up the transport process. The main uses of ultrafiltration and reverse osmosis are that they permit separation of dissolved molecules down to the ionic range provided the appropriate membrane is used. RO retains all components other than the solvent (water) itself while UF retains only macromolecules or particle larger than 0.001 μm - 0.02 μm. Microfiltration (MF) processes, on the other hand, are designed to retain particles in the 'micron' range (0.01 μm-10 μm) as shown in Table 2.

Ultrafiltration

Ultrafiltration is a pressure driven membrane separation technique for dissolved and suspended materials based on size and molecular scale. Substances smaller than the pore size of the filter are driven through with the solvent, while large solutes are retained. This is a very simple procedure and requires no phase change, no chemical addition and little energy (Fig. 1). UF membranes have got unique skinned or anisotropic structure. The tight pore structure opens to a more porous network below. This allows retention to take place on the membrane surface rather than within the filter structure. Filtration rates are also greatly increased since the major flow resistance of the membrane surface structure is extremely thin (Fig. 2).

Reverse Osmosis

Reverse osmosis in its broad sense is a technique to de-water the fluid mixture by means of semi-permeable membranes. RO can be explained on the basis of preferential sorption capillary flow mechanism and it is based upon Gibbs adsorption isother-

Table 1 — Characteristic of ideal membrane processes

Sl No.	Process	Driving force	Permeate	Retentate
1	Osmosis	Chemical potential	Water	Solutes
2	Dialysis	Concentration difference	Water and small molecules	Large molecules
3	Ultra Filtration	Pressure	Water and small molecules	Large molecules
4	Electro-dialysis	EMS	Water and ionic solutes	Non-ionic solvents
5	Reverse osmosis	Pressure	Water	Solute
6	Micro-filtration	Pressure	Water and dissolved solutes	Large suspended particles

Table 2 — Membrane-pore size & pressure requirement

Sl No.	Process	Pressure required (in psi)	Pore size (μm)
1	Ultra filtration	10-100	0.001-0.02
2	Reverse osmosis	500-10,,000	0.0001-0.01
3	Micro-filtration	10-100	0.01-10.0

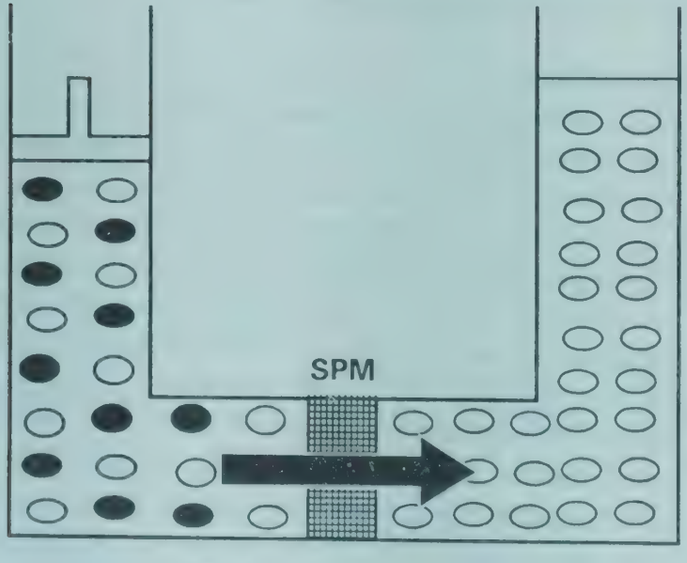

Fig. 1 — Principle of ultrafiltration

mal model in which solvents containing salts will have a negative access of the solute adsorbed on the membrane surface, i.e. there will be a layer of water molecules on the membrane surface (negative access of solute molecules for membrane means the membrane has no affinity towards solvent molecules, i.e. water molecules). If the membrane has pores of

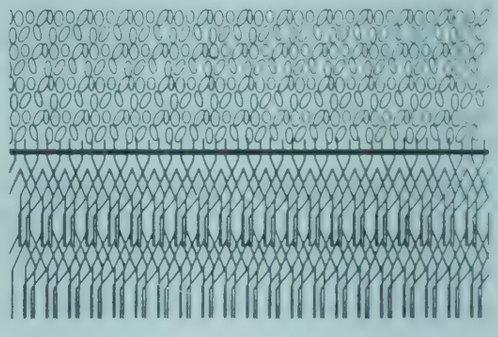

Fig. 2 — Anisotropic membrane

approximate size (i.e. twice the thickness of the water layer) and pressure to over come the osmotic pressure of chemical potential difference is applied, the adsorbed solvent,i.e. water layer will pass through the pores of membrane (Fig. 3).

The RO and UF consist of pumping the feed solution under pressure over the surface of suitably supported membrane of the appropriate chemical nature and in the optimum physical configuration. The pressure gradient across the membrane would force solvent and smaller species through the pores of membrane while the large molecules would be retained. The retained phase or *"retentate"* or *"concentrate"* stream as reference to will thus be enriched in the retained macromolecules while the permeate stream will be depleted of the macromolecules. The permeate will also contain some solutes. In fact, it may be very similar or of higher concentration than

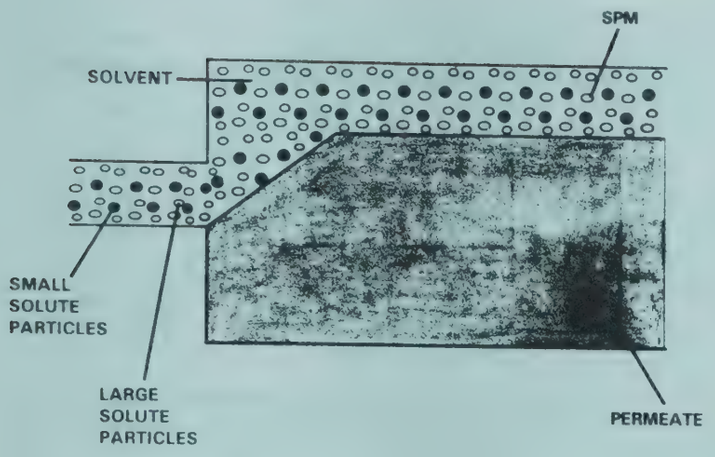

Fig. 3 — Principle of reverse osmosis

in the permeate stream, depending on the component rejection by the membrane. However, since the retentate now forms a much smaller volume than the feed, there has been a *"purification"* of the retained species.

Membranes

The basis of these processes is the semi-permeable membranes. They must possess following characteristics for successful and useful operations.

(i) High hydraulic permeability to solvent or water.

(ii) Sharp molecular weight cut-off.

(iii) Good mechanical durability, chemical and thermal stability.

(iv) High fouling resistance.

(v) Easily cleaned and sterilized.

(vi) Long membrane life.

Composite Membranes

It consists of an extremely thin layer ($<\mu m$) of very high pore selectivity. It is supported on a much thicker (20 μm-1m) layer of deporous open called sponge. If required, these membranes can be further supported by a fibrous sheet (e.g.paper) to provide greater strength and durability.

Membrane Preparation

Traditionally, cellulose has been the most common material for membrane structure. The casting technique generally involves 'first rendering the cellulose soluble, then evaporating and precipitating it to form a membrane'. It can be made soluble by several methods:

(i) By nitration of (-OH) group, then dissolving in an alcoholic or other solvent, and finally precipitation or evaporation.

(ii) By treatment with a strong caustic solution followed by CS_2.

(iii)By dissolving purified cellulose in $CuSO_4/NH_3$ solution and then coagulating in water and washing in acid.

(iv) By reaction with acetic acid to form cellulose acetate.

Liu *et al.*[1] have compared the composite model and concentration polarization gel model and shown that the composite model was more advantageous and coincided with the experimental data better by taking account of the entire membrane surface including the portion before the formation of gel layer.

Preparation of Composite Membrane

A film of cellulose acetate is deposited by dipcoating the supporting layer with a diluted layer solution. Recent methods include phase inversion process and other membrane include polycarbonates polyacrylnitrate, polyvinyl chloride, copolymer, and polysulphones.

Preparation of Skinned Membrane

Skinned membrane can be prepared from a solution of cellulose acetate in acetone. A thin layer is evaporated for 3 min, coagulated in cold water at 80°C. The top layer forms a thin homogeneous membrane with a very high perm- selectivity and the lower layer yields a supporting matrix of a highly porous structure.

Preparation Methods

Several methods described by researchers are as follows:

(i) Precipitation by evaporation

(ii) Precipitation from vapour phase

(iii)Thermal precipitation

(iv) Immersion precipitation

(v) By sintering of powders

(vi) By extension or stretching using laser beams or collimated charged particles.

A new method for preparing an inorganic UF membrane made of magnesium-aluminium-spinel (Mg-Al) has been described by Pflanz and Stroh[2] in

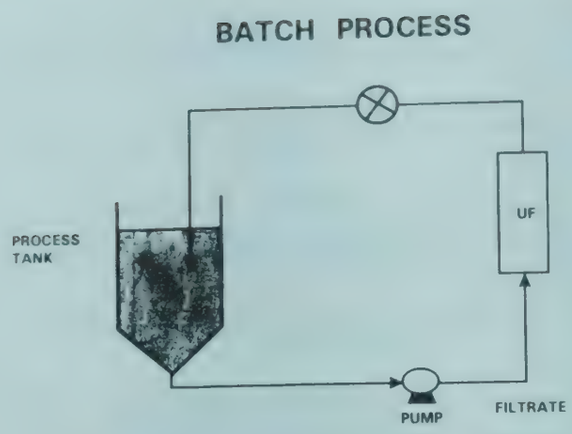

Fig. 4 — Comparison of batch & single stage continuous system

1995. This membrane is supported by a flat ceramic microfilter processed via the tape casting process.

Characteristics of some commercial membranes are given in Table 3.

Factors Affecting Membrane Structure

Performance of a membrane depends on the process by which it is manufactured. Mainly the composition and temperature of gelation media is important.

(i) Decrease in solvent to polymer ratio or an increase in non- solvent to polymer ratio into casting solution composition or decrease in casting temperature, increases the average pore size.

(ii) Increase in solvent to polymer ratio increases the effective number of pores on membrane surface.

(iii)Increase in pore on the membrane.

System Design

Two types of systems in use are : (i) Batch and (ii) Continuous.

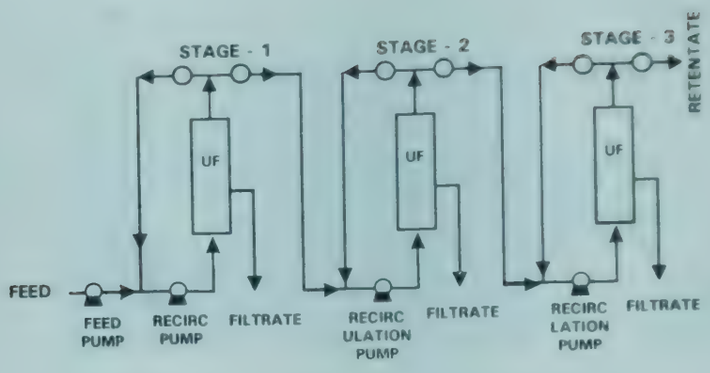

Fig. 5 — Multistage continuous system

(i) *Batch*

The fluid is removed from a process tank, pumped through the UF unit and returned to the tank. The concentration of the product gradually increases as the filtrate is withdrawn. In this manner, the filtration flux rate is initially high and decreases steadily during the process.

(ii) *Continuous*

The fluid is introduced in a recirculation loop by means of a feed pump which maintains a proper velocity and pressure at the membrane surface. The concentration is varied continuously from the system so that the ratio of feed to concentrate flow equals the specified concentration factor. When the steady state is achieved, the system will contain fluid at the final and maximum concentration. Consequently, the flux rate will be at a minimum throughout the run. The comparison of batch and single space continuous system defined by Tutungian[3] is shown in Fig. 4. If a continuous process is used it is usually more economical to use a multistage system Fig 5.

Membrane Bioreactors

Roger *et al.*[4] have classified membrane bioreactors into two major categories.

(i) Those which involve continuous cell recycle via a suitable membrane module.

(ii) Those based on a hollow fibre system to entrap cells or enzyme.

According to Rogers *et al.*[4] the major advantage of the former system is its potential for achieving high bioreactor productivities, while the latter can offer additional advantage with products from shear sensitive plant and animal cells. Their main disadvantage is that they cannot be scaled up. Moreover,

Table 3 — Characteristics of some commercial membrane

Sl No.	Membrane series	Manufacturer	Composition	Flux at 55 psi(cm/h)	Mol cut off (x1000)	Working Max. temp(°C)	pH Units
1	PEM	Gelman	Cellulose	1.2	60	—	—
2	U M diaflo	Amicon	Polyelectrolyte	0.6-1.8	0.5-10	50	2-12
3	X M diaflo	Amicon	Substituted olefins	60-120	50-300	75	2-12
4	P M diaflo	Amicon	Aromatic polymer	90-300	10-30	115-121	2-12
5	X M diaflo	Amicon	—	1.2-120	1-30	75	2-12
6	PSED	Millipore	Cellulose ester	8	50	—	—
7	HFA	Abcor	Cellulose	50-80	10-30	50-63	2-9
8	C A	DDS	Cellulose	8-12	6-60	50	2-8
9	GR,,FS	DDS	Copolymer	4-15	6-60	80	2-14
10	T2/A-T5/A	PCI	Cellulose acetate	2-3	4-10	30	2-8
11	BX1, BX2	PCI	Polyacrylo nitrite	3.2-5	30-100	70	2-13

they have mass transfer limitation of nutrients and/or products in aerobic processes.

In the membrane recycle bioreactors, membrane modules continuously separate the cells from fermentation broth and recycle them back to culture vessel. The product is withdrawn from the permeate stream.

In the hollow fibre type of bioreactors, cells are confined on one side of the membrane (usually the shell side of the hollow- fibre cartridge) and fluid flow occurs on the other (e.g. tube) side. The design is comparable to a plug flow reactor with some modifications.

Beaubien *et al.*[5] developed a new generation of UF membrane which are more productive and less expensive. This has prompted the emergence of membrane bioreactors in the design and operation of waste treatment plants. Beaubien *et al.*[5] studied the detention of the optimal operating conditions of an aerobic membrane bioreactor: The influence of biological and physicochemical parameters on the overall performance was evaluated.

They found that performance of the biological component of the system depends mainly on the mass loading. They developed a filtration testing procedure and established several relationships between the various operating parameters of a membrane bioreactor.

Membrane Fouling

The fouling process which has been described as pore plugging or the formation of a slowly consolidating gelatinous layer on the membrane surface or protein polymerization is very unpredictable and appears to vary markedly depending on the membrane composition, the nature of the retained solute, and other variables such as solution's pH, ionic strength, electrolyte composition, temperature and operating pressure.

Fouling occurs at two stages:

(i) The first is due to the adsorption of the solute to the membrane within 10 min of contact between the protein or solute with the membrane.

(ii) The second stage is manifested by a relatively slow continuous decline in permeation rate that is substantially independent of feed to solute concentration and upstream hydrodynamic condition.

Treatment

The techniques of treatment for processed cheese whey consist of the following methods : heat treatment, pH adjustment, pH and ionic adjustment, Ca sequestering by EDTA prefiltration.

Membrane Characteristics

Charged membrane	Electrodeposition paint
Enzyme coating	Protein
Hydroplutic precot	Cheese whey

Cleaning

Backflush	Several
Foam balls	Sea water
Biological detergents	Cheese whey
Oxalic acid	Oily wastes
Hydrogen peroxide	Proteins
Hypochloride	Cheese whey

Advantages of UF and RO

(i) UF together with RO constitute the first continuous molar separation process that does not involve a phase change or interphase mass transfer.

(ii) The pressure involved in UF is fairly low.

(iii)Absence of a change in phase or state of the solvent during the de-watering process unlike the other conventional de-watering processes, such as evaporation, freeze concentration, and freeze drying.

Limitations

(i) Neither UF nor RO can take the solute to dryness.

(ii) Poor cleanability of some early molecules.

(iii) Restricted operating conditions.

Applications

1 *General*

(i) Separation and harvesting of enzymes and microorganism.

(ii) Continuous high performance bioreactors for enzymatic and microbial conversion processes.

(iii) Tissue culture reactor systems.

(iv) Production of pure and high quality water.

(v) In dairy industry, for fractionation of cheese whey and pre- concentration of milk.

(vi) In the process of water treatment to remove pyrogens.

(vii) Treatment of oily waste water.

(viii) Sugar refining.

(ix) Vegetable protein processing.

(x) In textile industry, to separate harmful synthetic sizing agents, such as polyvinyl alcohol (PVA) and carboxy methyl cellulose (CMC) in cotton blends.

(xi) Egg processing.

(xii) Paper and pulp industry.

(xiii) Tanning and leather industry.

(xiv) Animal product industry.

(xv) In recovery of printing ink.

(xvi) In homodialysis.

(xvii) To supplement kidney functions (Dialysis is also helpful in this field).

(xviii) Manufacture of fruit juices and other beverages.

(xix) In wine industry, before fermentation for clarifying the must; and, after fermentation, for treating the finished wine.

(xx) In stabilizing proteins.

(xxi) Reducing polyphenols.

(xxii) Removal of all undesirable microorganisms.

2 *Ultrafiltration*

(i) In 1970, Ghose *et al.*[6] proposed a model system for the continuous steady state saccharification of ground substrate (Solka Floc) in which there is a continuous removal of concentrated glucose syrup and a feedback of enzyme cellulase. Cellulase of *Trichoderma viridae* was concentrated by various molecular cut-off membranes and their activities were studied under UF condition. Little or no cellulase was discharged through the membrane, reasonably high mass flux values (9.7-23.3 gals/ ft^2/d) were obtained in separating glucose from a digest of 30% cellulose suspension. The most suitable membrane used by the authors was Amicon- PM-10 with molecular weight cut-off of 60,000 Da.

(ii) End-product inhibition of biological reactions remains a fundamental bottle-neck of bioprocesses because it decreases the production rates and increases the volumes handled and cost of separation. Minier *et al.*[7], developed an extractive actinobutyric fermentation process by integrating bioproduction UF and distillation, providing simultaneous retention of biomass, selective removal of inhibitors from the permeate as well as separation and purification of acetone-butanol- ethanol solvents. In their work, they used UF as a retention method of microorganism for achieving high cell-density cultures of *Clostridium acetobutylicum* and as a selective barrier between biological retention and downstream processing.

(iii) Prazers *et al.*[8] devised an UF membrane bioreactor for the lipolysis of olive oil in reversed micellar media. The enzymatic hydrolysis of olive oil using *Chlromalbacterium viscosum* lipase-B encapsulated in reverse micelles of dicotyl sodium sulphosuccinate (DSS) in isooctane was investigated in an UF

ceramic membrane bioreactor of tubular type, operating in a batch mode.

(iv) Lipford *et al.*[9] devised a method for separating bound versus cell bound label during radio iodination. The technique employed the use of membrane UF technology and returns in one step a highly reproducible product of quality superior to that attained by gel chromatography.

(v) Nakano *et al.*[10] reported on increase in the rate of cell-free protein synthesis by condensing wheat germ extract with UF membrane. The most common problem frequently encountered with UF is membrane fouling.

(vi) Antifoam which is frequently added to fermentation broth to suppress foaming often fouls membrane. Yamagiwa *et al.*[11] have studied the effectiveness of surfactant precoat treatment of the polysulphone ultrafilter for reduction of membrane fouling in UF of antifoam.

(vii) Gomez-Gotor *et al.*[12] studied the experimental data and behaviour of starch/water solution on UF module. They analysed the contribution of fouling and gel resistances. They evaluated the diffusion after the Grover and Shilton-Colburn equation.

(viii) A rapid and efficient method for concentration of small volume of retroviral supernatant was developed by Miller *et al.*[13].

In their study, they used Amicon UF membrane with a molecular weight cut off of 100,000. They obtained a final retroviral concentration of about 2 mL from a starting volume of 100-150 ML and the concentration time is normally 2.5 h.

(ix) The author had used Amicon Ultra Filtration Membrane No. PM- 10 for separation of cellulase enzyme from fermented broth. The processes for cellulase production developed by Pathak[14] for surface culture method and submerged culture method were published earlier[15]. In these processes, the author had used Amicon-PM-10 Ultra Filtration Membrane with molecular cut off range of 60,000 Da and above to retain cellulase enzyme in the concentrate. In the year 1975, while working with M/s Alembic Chemical Works Company Limited, Baroda, the author has used Amicon Ultra Filtration Membrane for cellulase enzyme production on pilot plant. In this process the fermented broth was filtered through a glass wool filter to obtain clear filtrate free from mycelium. If the filtrate was not clear it was passed through Sharples centrifuge. The filtered enzyme solution was buffered to pH 4.8 and was preserved with 0.0005% merthilate and kept at 4° C.

This cellulase enzyme solution was passed through a Ultra Filtration Membrane PM-10, fitted in Amicon Membrane kit supplied by a US company. Solution was passed under stirred conditions with the help of a magnetic stirrer with positive pressure of 20 PSI. The concentrate so obtained was 40 times concentrate (40 L to 1 L). The cellulase enzyme was precipitated from this concentrate. The data so obtained in the year 1976 and 1977 on pilot plant scale are given in Table 4.

The processes developed by author using Ultra Filtration Membrane have also been published earlier.

3 *Reverse Osmosis*

(i) For the concentration of whey, RO was used. Because solute rejection depends on temperature, flow-rate turbulence, and feed characters membrane characters can only be defined for space condition, molecular weight cut off and salt rejection values as specified by the manufacturer are useful as general guides only, e.g. the same operating conditions will allow a great proportion of small nitrogenous compounds from acid whey than from sweet whey. Generally, G and P do not readily pass through the membranes and cause membrane fouling. Potassium and sodium chloride ions as also lactic acid are more readily lost in the permeate.

The advantages of whey concentration by R O are:

(a) Minimum pollution.

(b) Reduced transportation cost.

(c) Pre-concentration.

(d) Less costly.

(e) And, more efficient process.

(ii) The problem of dilute solvent concentration in acetone- butanol fermentation can be solved by using RO to de-water the fermentation liquors (Garcia et al.[16]).

Polyamide membranes were used for this purpose. The process consists of passing the fermentation liquor through an UF hollow fibre cartridge to remove suspended solids. The UF concentrate of suspended solids, composed mostly of vegetative organisms, was used as a cell recycle stream for the fermentor.

Table 4 — Summary of cellulase production by culture (C3), i.e.(*Tricoderma viridae*) on pilot plant scale 27th July' 77

Date	Run No	Run Size L.	Name of medium and unit	Water used in medium	Amount of tween 80 used %	Agitation and Aeration No. of impellers rpm	Nos	in vvm	pH Initial	Controlled to	Fermentation time, h	FP Activity /ml of C F	Freeze dried cellulase (g)	FP activity/mg of powder	Protein/mg of powder	IU/mg of powder	IV/mg of proteins	Remarks
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
25.11.76	F1/76	30	Ammonium Sulphate medium	DM water	0.2	424	2	0.5	5.2	5.0-5.2	282	4.4	29.20	2.22	0.38	0.205	0.513	Good yield, poor growth
06.12.76	F2/76	50	unit. A	"	0.2	424	2	0.5	5.2	5.2-5.6	210	0.5	—	—	—	—	—	Not processed
15.12.76	F3/76	03	Continuous culture	"	0.2	250	2	0.5	5.2	5.4	240	3.68	3.235	1.14	0.25	0.105	0.42	Poor activity
27.12.76	F4/76	50	Unit C	"	0.2	424	2	0.5	5.2	5.4	240	4.8	55.50	2.08	0.40	0.192	0.48	Good activity
15.01.77	F1/77	50	Unit C	"	0.2	424	2	0.5	5.2	5.4	234	0.46	—	—	—	—	—	Not processed
31.01.77	F2/77	30	Unit C	"	0.2	424	2	0.5	5.0	5.2	232	0.46	—	—	—	—	—	— do —
14.02.77	F3/77	05	Continuous culture	"	0.0	300	2	0.4	5.0	5.1	240	2.68	3.520	1.16	0.25	0.107	0.43	Poor activity
03.03.77	F4/77	30	Unit C	DM Water	0.2	424	2	0.5	5.0	5.2	136	3.12	17.3	1.36	0.35	0.126	0.36	— do —
10.03.77	F5/77	50	Unit C	"	0.2	424	2	0.5	5.0	5.1	258	4.32	30.1	2.12	0.368	0.196	0.532	Good activity
25.04.77	F6/77	50	Unit D	"	0.2	424	2	0.5	5.0	5.2	240	4.96	36.25	2.26	0.43	0.209	0.486	— do —
06.05.77	F7/77	50	"	Tap water	0.0	424	2	0.5	5.0	5.2	240	2.52	—	—	—	—	—	Not processed

— Contd

Table 4 — Summary of cellulase production by culture (C3), i.e.(*Tricoderma viridae*) on pilot plant scale — (Contd

Date	Run No.	Run Size L.	Name of medium and unit	Water used in medium	Amount of tween 80 used %	Agitation and No. of impellers rpm	Nos	Aeration in vvm	pH Initial	Controlled to	Fermentation time, h	FP Activity /ml of C F	Freeze dried cellulase (g)	FP activity/mg of powder	Protein/mg of powder	IU/mg of powder	IV/mg of proteins	Remarks
27.05.77	F8/77	50 " (CSL medium)			Dm water	0.0	424	2	0.5	5.0	5.2	240	3.36	—	—	—	—	—	Not processed
08.06.77	F9/77	50	"		Tap water	0.2	424	2	0.2 0.5 (48h)	5.0	5.2 5.2 (48h)	240	5.12	64.80	1.86	0.35	0.172	0.491	Good activity
21.06.77	F10/77	50	"		"	0.2	424	2	0.2(after -wards)	5.0	4.0 up to end	240	4.12	31.5	2.44	0.512	0.225	0.43	Good activity
05.07.77	F11/77	50	"		"	0.2	424	2	0.5(0-48h 0.2(up to end)	5.0	5.2 (48h) 4.0(up to end)	240	4.00	—	—	—	—	—	Processed and good activity (confidential)

C F =culture filtrate; According to latest report of U.S. Army Natick Development Centre*, (USA), specific cellulase activity of final soluble protein is in all cases between 0.7 and 0.8 International Units (I.U.) per milligram of Protein. Because enzyme concentration of culture filtrate is being carried out at room temperature in our laboratory, there is considerable loss of enzyme activity during processing. Attempts will be made to enhance activity in culture filtrate and to minimise loss of activity during processing by manipulating process variables and using better fermentation conditions.

* Nystrom, J M & Andren R K, "Pilot Plant Conversion of Cellulose to Glucose", *Process Biochem, London*, **11** (1976) p.26.

A RO system was used as a continuous extraction system for the removal of the toxic end product, butanol. Continuous removal of butanol would permit continuous fermentation with a high substrate level, resulting in an increased production rate of butanol.

The conclusions drawn by the above mentioned process are :

(a) Solventogenesis is not always easily induced and maintained.

(b) Hollow fibre UF is adequate as a pretreatment for RO; however, it develops low productivity as a result of fouling and plugging and can be cleaned to restore about 95% of initial productivity.

(c) Ninety percent of butanol can be removed at recoveries as high as 70%.

(d) Flux through the RO membrane is reduced for the fermentation liquor to about one-third the flux of an aqueous mixture because of the added constituents.

(e) Butanol rejection values of 98% are possible at recoveries of 20-25% when de-watering a fermentation liquor and are not affected by pressure.

(f) The solvent (Butanol/acetone) can be concentrated about three-fold at recoveries of about 70%.

(g) Integration of membrane technology can overcome the problem of low productivity yield and dilute solvent concentration associated with the production of butanol by continuous fermentation.

(iii) Ikushima *et al.*[17] developed a method for purification of sulphonated sugar by RO membrane with an inhibition rate of =1 % to =P% against a 1,000 mg/L NaCl solution and the fractionation molecular weight of 100-5000 is operated at pressure 1-5 kg/cm^2. They efficiently desalinated a low molecular weight sulphonated sugar having a molecular weight close to those of the inorganic salts to give the sulphonated sugar a high purity in contrast to a process using a SPM or UF method in which both the sulphonated sugars and inorganic salts permeate.

(4) *Membrane Chromatography*

This technology was introduced earlier for protein purification. The special features of this technology are :

(a) Absence of pore diffusion, which is mainly transport resistance in conventional method.

(b) With low pressure drop across the membrane, high volumetric flows are possible in a membrane based purification step thereby reducing time for separation cycle.

The usefulness of this new technology in the purification of many proteins has been reviewed in detail by various authors[18].

Concluding Remarks

The UF and RO processes have been widely accepted for enhancing the utility of membrane technology for increasing the concentration of solute as well as for purification of various solutions. Work is being done to improve these technologies so that they can be economically used for the separation processes. It is anticipated that in near future, the problem of membrane fouling will be reduced. These technologies are time saving as well as economical as compared to traditional separation and concentration techniques and with minimal changes in the microenvironment. The membrane technology has been proved to be most successful for above mentioned purification and concentration processes.

In the long run, it is expected that membrane-based chromatography will be a technology of future in separation of proteins. To scale-up the technology, engineering approach based on analysis shall be followed. Significant product purification can be achieved by this new technology. The author feels that this technology will be adopted for industrial purification processes for proteins and enzymes in near future worldover during early 21st century.

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Group Technology Cell Formation Using Stochastic Search Technique

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Group Technology (GT), as a manufacturing philosophy, seeks to identify and exploit similarities of product design and manufacturing process throughout the manufacturing cycle. The most important problem in implementation of GT is the identification and formation of the machine cells. This paper demonstrates the relative effectiveness of an enhanced Guided Evolutionary Simulated Annealing (GESAX) for determination of Group Technology machine cells. Guided Evolutionary Simulated Annealing (GESA) is a stochastic search technique for combinatorial optimization problems derived to combine the benefits of both Simulated Annealing and Simulated Evolution. GESAX is an enhanced form of GESA with the standard Genetic operators crossover and mutation incorporated, improve the efficiency of search process. The GESAX algorithm is provided with a part-machine matrix. The algorithm then searches for suitable cells with high Grouping Efficiency and Grouping Efficacy. The computational experience with several problems taken from the literature is presented. The measures, Grouping Efficiency and Grouping Efficacy are computed and compared with the results obtained on the same problems by ART-2 Neural Networks and two clustering algorithms, GRAFICS and ZODIAC, which are known clustering methods available in the literature. These results indicate that GESAX is an effective approach for rapid creation of "good" GT cells. Also, the high speed and inherent parallelization capability of GESAX makes it ideal for large industry sized problems. The formulation of the GT cell formation problem as an optimization problem gives scope for incorporating various constraints that are to be satisfied in any real implementation of the procedure.

1 Introduction

Group Technology (GT), as a manufacturing philosophy, seeks to identify and exploit similarities of product design and manufacturing process throughout the manufacturing cycle[1]. Similarity between parts can be based on the design and/or manufacturing attributes. Design attributes may include the part's geometric shape or dimensions whereas manufacturing attributes may include part routes, tools or production time and volume. The manufacturing engineer may improve the efficiency of manufacturing be creating GT cells such that a similar set of parts is manufacturing in an independent cell. This not only reduces the materials movement but also improves the manufacturing efficiency[2]. The most important problem in implementation of GT is the identification and formation of the machine cells. In the cell formation problem, information is typically provided in the form of a machine-part matrix A, with element A_{ij} indicating whether part j required machine i ($A_{ij} = 1$) or not ($A_{ij} = 0$). The main objective is to create machine cells, identify part families and allocate part families to machine cells so that the inter-cellular movement of parts is minimized.

Over the years, a number of methods have been developed for the cell formation problem. McAuley[3] first proposed the use of single linkage cluster analysis, based on the Jaccard Similarity Coefficient.

Similarity coefficient based methods have been widely used since then, by Waghodekar and Sahu[4], Sieffodini and Wolfe[5], Wei and Kern[6] and many others. Graph theory was first introduced for this application by Rajagopalan and Batra[7]. Production Flow Analysis (PFA), pioneered by Burbidge[8] and Component Flow Analysis[9] are comprehensive hierarchical methodologies. Both the methods require subjective and non-quantifiable inputs into the decision process, and include several tasks, among which part-machine grouping is the most challenging problem[10]. Clustering is known to be NP-complete, and hence, for large scale problems heuristic procedures are widely used. Even these require substantial computational effort[11].

Artificial Neural Networks techniques have only recently been used for this problem. Currie[12] presented a technique that used a self-organising neural network model — the Interactive Activation and Competition model (IAC), that identifies the part families by considering the design and manufacturing similarities simultaneously. Kusiak and Change[13] applied the Carpenter-Grossberg Neural Network model to identify the part family/machine-cell combination. Kaparthi and Suresh[10] used neural network for forming machine-component cells for manufacturing as many as 10,000 parts. Venugopal and Narendran[14] present a study with competitive learning model, the Adaptive Resonance Theory (ART) model and the Self-Organising Feature Map (SOFM) model. The ART-1 model is restrictive in the sense that it can accept only binary vectors. Another major drawback is that the clusters formed depend on the sequence of presentation of the patterns[10]. Chen and Srivastava[15] recently proposed Simulated Annealing to solve a quadratic programming model for forming machine cells. Patvardhan *et. al.*[15a] demonstrate the applicability of the ART-2 Neural Networks and show that cells with good efficiency and efficacy can be obtained utilizing the pattern recognition capabilities of the ART-2 Neural Networks. They also propose the use of the traditional similarity coefficients with ART-2 to reduce the size of the training set. All the existing methods with the exception of the neural networks methods, are serial algorithms requiring significant time for processing. Moreover, these methods also require storage and manipulation of large matrices and virtually always focus on binary attributes. Haragu[16] and Offodile *et.al.*[17] provide excellent reviews and classification of the numerous techniques available for cell formation.

In this paper, we demonstrate the relative effectiveness of GESAX, a stochastic search technique for combinatorial optimization problems for determination of Group Technology machine cells. GESAX is provided with a part-machine matrix. The output is a set of machine cells which are created by searching for machine-cell assignments that maximize the "fitness", i.e. Grouping Efficiency or Grouping Efficacy. Parts are assigned to the machine cells so that most of the machines required by each part are available in its cell. The measures Grouping Efficiency and Grouping Efficacy are calculated to determine the quality of cells formed. We compare these results with those obtained using algorithms ART-2 Neural networks with binary and Similarity data as inputs[15a], GRAFICS[18] and ZODIAC[19] which are known to be some of the better existing approaches. As GESAX is amenable to parallel processing, it is applicable to large real-life industry problems.

The rest of the paper is organised as follows. Section 2, provides a description of the GESAX algorithm. The applicability of GESAX to GT Cell formation is discussed in Section 3. In Section 4, the results of computational experience on various standard data sets taken from the literature are reported, followed by some conclusions and directions for future work in Section 5.

2 Enhanced Guided evolutionary Simulated Annealing (GESAX)

Many techniques for finding sub-optimal or near-optimal solutions have been proposed for the NP-complete problems as finding the optimal solution is computationally prohibitive. Simulated Annealing[20] and Simulated Evolution[21] are two such techniques. These are powerful optimization techniques with origins in nature. GESA is a hybrid technique obtained by the incorporation of the process of Simulated Annealing into the selection process of Simulated Evolution[22]. GESAX is the enhanced form of GESA in which the GA operators crossover and mutation has been introduced to speed up the search process. Thus, GESAX is a search technique that enables us to search the solution space for highly "fit" individuals, i.e. those with better objective values in any optimization problem. The GESAX algo-

rithm can be expressed concisely in the form of a pseudo-code as given in Figs 1 and 2.

3 Group Technology Cell Formation with GESAX

In this section the implementation details of the GESAX algorithm for the solution of the Machine-Cell formation problem are described.

3.1 Methodology

The input to the method is the machine-part incidence matrix of size m x n where m is the number of machines and n the number of parts. The entry a_{ij} in the matrix is 1 if part j is processed on machine i and 0 otherwise. The user is also required to specify the minimum and maximum number of machines in each cell and the maximum number of cells.

The GESAX search technique starts out with a guess of N likely candidates strings of integers (parents) chosen at random in the search space. Higher value of N enables a more exhaustive choice of the search space with correspondingly greater computational effort. In our implementation we have chosen N =30 as a reasonable compromise. Care is taken to generate only those initial candidates that satisfy the size constraints. A standard coding method for classification problems is chosen for representing the search space. Each string is of length equal to the number of machines. Element $a[i]$ of string a indicates the cell to which machine i belongs. For example 1 2 1 3 3 2 string indicates that machines 1 and 3 are in cell 1, machines 2 and 6 are in cell 2 machines 4 and 5 are in cell 3.

Initially each parent generates M = 10 children. The children are generated by applying the Genetic Algorithm (GA) operator crossover on the N candidates. Essentially, the children of a parent are points

```
Step 1 Set initial temperature t
Step 2 Randomly select N= 30 parents
Step 3 Generate M= 10 children from the
       parents by performing crossover
Step 4 Replace a child by its parent, if
       the    number of machines in any
       cell is less than the minimum cell
       requirement.
Step 5 Find the best child for each parent
       (Ist level competition or local
        competition)
Step 6 Find the parents for the next
       generation (selection)
For each family, accept the best child as
the parent for next generation using the
Boltzmann criterion.
Step 7 Perform mutation on Step 5 and find
       the resultant parents for the next
       generation.
Step 8 Find the number of children that
       will be generated from the parents
       of the next generation (second level
       competition). The details of this
       step are given in Fig.2.
Step 9 Decrease that temperature
Step 10 Repeat Step 3 to Step 8 until a
       certain number of evaluations
       (10000) has been reached.
```

Fig.1 — GESAX algorithm

```
  Step 1 Repeat Step 2 to Step 5 each
       family; Goto Step 6
Step 2 count = 0;
Step 3 Repeat Step 4 for each child; Goto
       Step 5
Step 4 If the Objective value of the child
       is lower than that of its patent,
       increase count by 1.
If not, then increase count by 1 consider-
ing Boltzmann criterion.
Step 5 Acceptance number of the family is
       equal to count
Step 6 Sum up the acceptance number of
       children generated can be
       calculated according to the
       formula

       M= (P*A)/S

where M is the number of children that
       will be generated for that family
P is the total number of points
A is the acceptance number for the family
S is the sum of the acceptance number
```

Fig.2 — Algorithm to find the member of children for the next generation

in its neighbourhood in the search space. We use the Goldberg's Crossover operator[21] to generate the children. The crossover operator proceeds in two steps. First, two parent strings are selected at random from the population. Second, two integer positions called crossover points along the string are selected randomly. Two new strings called child strings are created by swapping all the alleles in between the two crossover points. Crossing over of two strings combines the features of both the strings. To generate M children for each parent, crossover has to be performed $M/2$ or $M/2 + 1$ times depending on whether M is even or odd.

For each parent the best child of the 10 children generated is determined. Since the objective is to maximize the Grouping Efficiency of Grouping Efficacy and the GESAX procedure is essentially a minimization procedure, we chose [100 - Grouping Efficiency (Grouping Efficacy)] as the Fitness function. The details of this function are provided in Section 3.2. The best child is the one with the lowest fitness value. If the fitness function value of the best child, y_1, is lower than that of its parent, y_2, then it is accepted as the parent for the next generation. However, if $y_1 > y_2$, we have the Boltzmann probability that the child be accepted where Boltzmann Probability criterion is give by

$\exp(Y_2\text{-}Y_1/T) > \rho$

where T is the temperature coefficient

ρ is a random number uniformly distributed between 0 and 1.

The selection of the temperature is such that initially the probability of acceptance of a bad move i.e. when the best child is worse than the parent is high but as the temperature is successively lowered, this probability is decreased till, at the end, the probability of acceptance of a bad move is almost negligible. It has been shown that the strategy enables the algorithm to seek the global optimum without getting stuck in some local optimum[20].

Mutation is performed on the population obtained as a result of the local competition (1st level competition) which contains the parents for the next generation. Mutation is the occasional (very small probability) random alteration of the value of a string position. It is performed by selecting a parent randomly and exchanging any two bit positions selected randomly. The probability of mutation determines the number of parents that will undergo mutation. Mutation is needed because occasionally crossover may become overzealous and lose some potentially useful genetic material[21].

The second-level competition is the competition between the families. The number of children that should be generated in the next generation depends on the results of the second-level competition. This second-level competition actually provides a measure of the fitness of each family. Each child has an objective value that is compared to the lowest objective value ever found, and acceptance number is calculated. The number of children allocated to each family for the next generation is proportional to that acceptance number but there are still a total of MN new candidate solutions. It has been shown that eventually only one family survives[22]. The family so found is the best one. The acceptance number actually provides the information of how good the region is. If a region is found to contain a large number of good candidate solutions (as measured by the acceptance number), we allocate more attention to search in that region. The above steps are performed repeatedly till the algorithm evaluates the required number of candidates. In our implementation we have chosen this to be 10,000 which represents a fair proportion of the search space. Eventually only one family survives. In that family, the candidate with highest Grouping Efficiency/Grouping Efficacy represents the best possible assignment of machines to cells as determined by GESAX.

3.2 Computation of the Fitness Function

Each candidate string in the final population represents as grouping of machines into various cells. The parts are first assigned to these groups according to the following procedure:

(i) For each part the number of machines in each cell that are used for processing the part are determined.

(ii) The cell in which the part needs the maximum number of machines is assigned the part.

(iii) If two or more cells are found in which the maximum number of machines used by that part are equal, the cell having lesser number of machines is assigned that part.

After determining the machine cells and the corresponding part families, the number of voids or zeroes and the number of exceptional elements are

calculated for the computation of Grouping Efficiency[23] and Grouping Efficacy[24]. If a part and a machine are in the same cell but the part is not processed by the machine, it is treated as a blank. If the part and the machine are not in the same group, but the part is processed by the machine, it is treated as one of the exceptional elements. The Grouping Efficiency and Grouping Efficacy are defined as:

Grouping Efficiency $= q(e-E)/(e-E+b) + (1-q)*(m*n-e-b)/(m*n-e+E-b)$

Grouping Efficacy $= (e-E)/(e+b)$

where,

q = 0.5 (for equal weightage for both terms in Grouping Efficiency. This parameter fixes the relative importance between blanks and intercell movements.)

e = Total number of 1's in the machine-part-indicator matrix.

$E(b)$ = Total number of exceptional elements (blanks).

$m(n)$ = Total number of machines (parts)

4 Results of Computational Experience

The algorithm has been tested on a number of standard GT cell formation problems taken from the literature. The measures Grouping Efficiency and Grouping Efficacy have been computed and compared with the results obtained on the same problems by algorithms ART-2 neural networks with binary inputs and similarity coefficients as inputs[15a], GRAFICS[18] and ZODIAC[19], which are known cell formation methods available in the literature. When the rows of the machine-part incidence matrix are provided to the ART-2 algorithm for clustering, it essentially reduces to ART-1 which can take only binary input vectors. However, ART-2 can classify real vectors also. Patvardhan *et. al.*[15a] propose the use of machine-machine similarity vectors where each element is determined by computing the similarity coefficient between the machines concerned. They show that this method drastically reduces the number of training patterns but does not significantly affect the solution quality. The performance of GESAX with results presented on the standard machine-part incidence matrices in literature using these methods[15a,18,19] is compared in Tables 1 and 2. These results show that GESAX based approach presented in this paper gives very good results with fast execution times and hence is very effective even for large sized problems.

5 Conclusions

GESAX is a practicable technique for the GT Cell formation problem as it provides good, near optimal solutions after examining a small portion of the possible solutions. This heuristic can be easily extended to consider other objectives by just modifying the evaluation of fitness function. The technique is easily amenable to parallel processing and so can be applied to large real-life industrial problems. The execution times are reasonably fast on a 486 66 MHz based PC. The formulation of the GT cell formation problem as an optimization problem and the use of a search technique for its solution give scope for incorporating various constraints[16] that are to be satisfied in any real industrial implementation of the procedure. Further extension of this work for consideration of multiple non- commensurable objectives in Group Technology is under progress.

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Table 1 — Grouping efficiency of cells obtained from ART-2 with binary inputs, ART-2 with similarity coefficients as inputs, GRAFICS, ZODIAC and GESAX.

S.No.	Problem	Size	ART-2 with binary input	ART-2 with Similarity coefficients input	GRAFICS	ZODIAC	GESAX
1	King *et.al.*[25]	16 x 43	79.62	79.67	79.4	80.2	81.13
2	Carrie[26]	20 x 35	87.81	87.81	87.81	87.81	87.81
3	Kumar *et. al.*[27]	23 x 20	78.71	82	76.16	66.97	76.42
4	King *et. al.*[25]	36 x 90	74.62	74.62	73.65	76.61	76.62
5	Data set 1[28]	24 x 40	100	100	100	100	100
6	Data set 2[28]	24 x 40	95.2	95.2	95.2	95.2	95.2
7	Data set 3[28]	24 x 40	89.94	89.94	91.16	91.16	89
8	Data set 4[28]	24 x 40	89.69	89.69	Not reported	85.04	87
9	Data set 5,[28]	24 x 40	78.1	75.24	78.86	77.31	80.08
10	Data set 6[28]	24 x 40	73.78	70.6	79.14	72.4	79.14
11	Data set 7[28]	24 x 40	78.53	79.35	79.13	69.33	78.6

Table 2 — Grouping efficacy of Cells obtained from ART-2 with binary inputs, ART-2 with similarity coefficient inputs, GRAFICS, ZODIAC AND GESAX.

S.No.	Problem	Size	ART-2 with Binary inputs	ART-2 with Similarity Coefficients inputs	GRAFICS	ZODIAC	GESAX
1	King et.al[25]	16 x 43	54.44	53.67	54.39	53.76	54.86
2	Carrie[26]	20 x 35	75.14	75.14	75.14	75.14	75.14
3	Kumar et.al.[27]	23 x 20	47.51	38.71	49.36	38.66	47.7
4	King et.al.[25]	36 x 90	39.48	39.48	39.41	32.73	40.44
5	Data set 1[28]	24 x 40	100	100	100	100	100
6	Data set 2[28]	24 x 40	85.1	85.1	85.1	85.1	85.1
7	Data set 3[28]	24 x 40	71.33	71.33	73.51	37.85	71.33
8	Data set 4[28]	24 x 40	71.39	71.39	Not reported	Not reported	71.33
9	Data set 5[28]	24 x 40	45.3	40.43	43.27	20.42	47.19
10	Data set 6[28]	24 x 40	38.97	34.15	44.51	18.23	44.51
11	Data set 7[28]	24 x 40	41.18	42.26	41.67	17.61	41.67

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Sisal (*Agave app.*) Fibre Extraction with 'Raspador' Decorticator

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Manual leaf feeding in two-directional action on 'raspador' decorticator is followed for fibre extraction, which restricts increase in its low capacity and unable to extract fibre from the leaf having marginal prickles. One-directional leaf feeding process was tested and showed fibre recovery equal to the two-directional action. Mechanical leaf feeding in one- directional action on 'raspador' decorticator was found feasible. The provision of a 'handle' (undecorticated butt-and) helps in washing, drying and cleaning of fibre.

Introduction

Sisal fibre production in India is low. Therefore, every year appreciable quantities of sisal fibre is being imported to meet the local demand. The cultivation of sisal in India, began almost at the same time as in East Africa. Agave plants are found in many parts of the country, but these are not utilized commercially for the fibre extraction. Out of the four species of *Agave* in India, except *A. sisalana* all others, *A. cantala, A. veracruz* and *A. wightii* are found widely. The leaves are with marginal prickles. The main problem in developing sisal fibre in India as a commercial crop is the limitation of its extraction and marketing of fibre[1,2].

The introduction of imported machine 'raspador' decorticator has made beginning in mechanical fibre extraction in India during early part of 20th century. During this period in East Africa, the 'raspador' decorticator was replaced by an automatic decorticators. This has made tremendous strides in fibre production. Later, in India also on some sisal plantations automatic decorticators were installed but, these machines were proved unsuccessful because of higher cost of fibre extraction. The automatic decorticator may not prove successful even on an area of 2,000 to 10,000 acres of sisal plantation and hence under existing conditions in India, it was recommended to extract fibre with 'raspador' decorticator machine only[2].

The 'raspador' decorticator needs manual labour to extract the fibre from sisal leaf. The fibre extraction capacity is low, extra manual labour is needed for leaf manipulation, workers' skin is often affected by the acid juice content of the leaf and handling the leaf with marginal prickles becomes difficult. To overcome these limitations recommendation was made for replacing manual leaf feeding with the mechanical method, which will not only eliminate human drudgery but improve quality and quantity of fibre production[2]. However, no work in this regard has so far been carried out in India.

The procedure of leaf manipulation on the 'raspador' decorticator involve two-directional leaf feeding and is done by manual labour. For the development of mechanical leaf feeding needs certain changes in the existing fibre extraction process. The automatic decorticator also extract fibre in two-directional action and thus has vastly complicated the design of the machine. In order to make the process simple and less expensive, suggestion was made to develop one-directional action in automatic decorticator with the provision of keeping about 10 cm long undecorticated butt-end of a leaf as a 'handle'[3,4]. Keeping this in view, this study was undertaken to investigate into the application of one-directional action in 'raspador' decorticator and its effect on fibre recovery.

Materials and Methods

The 'raspador' decorticator is a simple machine based on the principle of *rapid beating and scraping* of a leaf progressively down its length. It is a strong cast-iron drum 40 cm diameter and 28 cm wide to which are bolted 12 angle-iron or beater knives on the periphery of drum. The drum is fastened to a horizontal shaft mounted in bearing that are fixed on to a firm stand. The rotating drum maintains clearance against the fixed knife or blade situated below the leaf feeding opening, for the rasping action.

Test were conducted on the freshly harvested matured sisal leaves. The leaves were collected from the randomly selected 21 plants from a uniform sisal plantation field Bamra (Orissa). The plants were 4-year-old and were harvested only once earlier. Forty-five observations were made on different dates consecutively for 21 days. Each observation consists of a set of 4 leaves of one plant. The selected leaves were more or less equal in length (107.5 cm) and weight (407 g). Each leaf was subjected to the following treatments (Fig. 1a):

Treatment A : Undecorticated leaf was cut transversely into 10 cm long pieces and weighed.

Treatment B : One-directional feeding action. Leaf was fed by the tip-end and was decorticated entirely except the butt-end portion using a leaf-gripping device.

Treatment C : Leaf was fed by the butt-end and decorticated about half of the leaf length.

Treatment D : Two-directional feeding action. This is the existing procedure. First, the leaf was fed by the butt-end and decorticated about 1/3 rd of its length; then by reversing, the same leaf was again fed by the tip-end to decorticate the remaining length.

For treatment B the leaf-gripping device was fabricated to hold the leaf by its butt-end towards operator. The machine and all operational parameters were kept constant. The machine was driven by a 5 hp diesel engine at a speed of 900 rpm. Fibre extraction was carried out manually by a single operator. The variation in green leaf weight due to different dates of harvesting were neglected. The fibre recovery of two-directional feeding (treatment D) was considered 100 per cent for comparing fibre recovery of one-directional feeding (treatment B). The data obtained were statistically analyzed.

Fibre recovery and fibre loss of each leaf were collected, sub- dried, cleaned and weighed. For comparing fibre recovery of treatments, the fibre were cut into 3 sections (Fig. 1a) and weighed. The first section is equal to the length of undecorticated butt-end ('handle') of treatment B. The second section is the middle blade portion. The last section is equal to the length of undecorticated laminar portion of treatment C. In order to compare the fibre recovery in treatment B and D and to estimate the amount of fibre loss due to 'handle' all the 3 sections were cut into 10 cm length pieces, and the fibre weight of each were taken.

To determine the fibre recovery percentage of two-directional feeding in a mass production, 10 observations on representative samples each containing 100 leaves were carried out. The green weight of leaves and dry fibre recovery were recorded.

The feasibility study of application of one-directional feeding by mechanical method on 'raspador' decorticator was carried out by fabricating the essential parts. The leaf-gripping device carrying leaf was

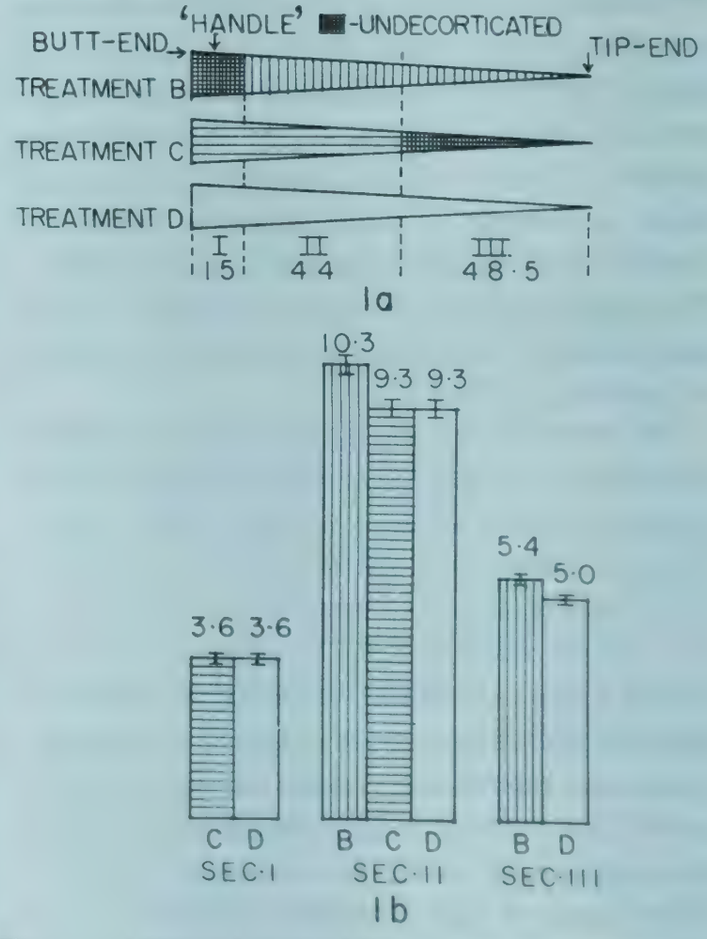

Fig. 1 — (a) Sectional details of fibre skeleton, length in cm and (b) sectional fibre recovery, weight in g

Table 1 — Comparison of recovery and loss of fibre in treatment B and D, Mean ± s.e.(c.v. per cent).

	Treatment B*	Treatment D
Fibre recovery g/leaf	15.70 ± 0.294 (12.53)	17.90 ± 0.318(11.90)
Per cent of green leaf weight	3.85 ± 0.043(7.49)	4.47 ± 0.057(8.59)
Fibre loss g/leaf	0.70 ± 0.153(140.58)	2.40 ± 0.112(31.40)
Per cent of dry fibre content in a leaf	3.70 ± 0.783(141.73)	11.62 ± 0.502(28.93)

*At 15 cm 'handle' length

Green leaf length — 107.5 cm ± 0.909(5.66); Green leaf weight — 407 g ± 7.222(11.88); Per cent dry fibre content in a leaf — 5.06 ± 0.055 (7.31); Decorticating efficiency of the machine — 88.38 ± 0.503(3.81)

made to move in forward and backward direction on reciprocating principle with the help of a lever rotated by hand. The fibre recovery percentage of a leaf was estimated.

Results

Table 1 shows the details of the leaf and its decortication and comparison of fibre recovery and fibre loss by the treatment B and D. It may be seen that by treatment B with 15 cm 'handle' about 88 per cent fibre recovery of treatment D may be achieved. However, the loss of fibre is greatly reduced by treatment B, as a major portion of fibre which goes as waste in treatment D is retained within the 'handle'.

The fibre recovery of treatments B, C and D are shown in Fig.1b. The fibre recovery in section II and III was found 1.4 g (7.8 per cent) more in treatment B, compared to the same in treatment D. Because of discarded 15 cm long 'handle' (undecorticated butt-end) in treatment B, about 2.2 g (12.3 per cent) less fibre recovery was obtained in comparison to the full length leaf decortication in treatment D. No significant variation was found in fibre recovery in treatment C and D.

The weights of leaf and fibre in corresponding sections along the leaf length are depicted in Fig.2. The figure shows higher fibre weight for B, than the same in treatment D and the rate of increment is more towards the butt-end. The figure also indicate that if certain length of leaf is further decorticated, there by reducing the 'handle' of treatment B to 10 cm only

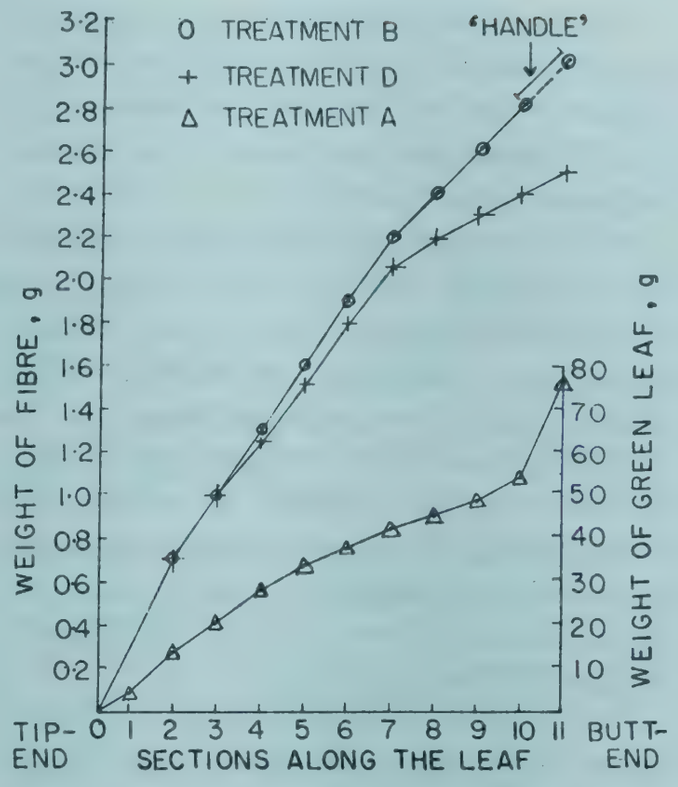

Fig. 2 — Variation in fibre recovery weight due to treatment B and D and distribution of leaf weight along the leaf length (average of 24 observations).

would add 2.8 g fibre in section close to the 'handle'. This means that more than 95 per cent of full leaf fibre (treatment D) is obtainable by treatment B.

The fibre recovery percentage in mass production in two- directional manual feeding was found to be 3.68 per cent (±0.077), which is lower than the experimental value of treatment D. By the application of one-directional feeding in a mechanical method the fibre recovery was found 4.2 per cent (±0.079) at 15.25 cm 'handle', which is higher than the experimental value of treatment B.

Discussion

More fibre recovery in sections II and III in one-directional feeding signifies that fibres are held together at the butt-end and when decorticated along the run of the fibre (i.e. towards the tip-end), they are not pulled out as is the case when the butt-end is decorticated against the run of fibre. The butt-end decortication always gives rise to higher losses than scutching the blade of the leaf[4]. The reduction in fibre loss in one-directional feeding further confirms the above observation.

The fibre recovery percentage in mass production in two- directional feeding was lower than the experimental individual leaf test value. The main reason for this is the manual leaf manipulation on the machine. Fatigueness of the operator results in erratic feeding which in turn affects the quantity of fibre produce. The mechanically achieved one-directional action can keep the leaf feeding constant in mass production and the resulting fibre recovery percentage will be higher or equal to the experimental value.

One-directional feeding provide a 'handle' which would be of great convenience in isolating fibre without tangling. The fibre skeleton would be locked and stable during washing, drying and cleaning operations. Finally, the cut off 'handle' can be used as the input for other useful usage.

The fabricated leaf-gripping device in the experiment could not achieve the desired 10 cm 'handle' length. But, it is possible to obtain 10 cm long 'handle', if the leaf gripping is achieved automatically in the mechanical feeder based on the reciprocating principle as suggested here and little modification carried out at the feeding site of the machine. The development of such a feeder machine is in progress.

Conclusion

(i) Sisal fibre extracted by one-directional action keeping 10 cm 'handle' (undecorticated butt-end) on 'raspador' decorticator showed fibre recovery nearly equal to the two-directional action.

(ii) The fibre recovery was lower in mass production when extracted manually by two-directional action compared to the one- directional action.

(iii) The adoption of one-directional action on 'raspador' decorticator was found feasible with the mechanical leaf feeding method based on the reciprocating principle.

(iv) The provision of a 'handle' with the fibre skeleton was found helpful in washing, drying and cleaning of fibre.

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Studies on Retting Methods to Produce High Yield Pulp for Newsprint Making

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Two pretreatment methods were used to prepare high yield pulps for newsprint paper, namely: water and acid retting. It was found that, the beatability of the fibres in case of water retting was improved on increasing the retting period up to 3 days, then it declined for longer retting periods. However, in case of acid retting, changing the acid concentration had insignificant effect on the beatability of the fibres. Acid pretreated samples needed longer beating time than water retted. Paper sheets were made by blending different ratios from each of the above pretreated pulps with local chemical bagasse pulp. The mechanical and optical properties of the obtained paper were evaluated for their suitability for newsprint making. The effect of addition of kaolin, rosin and phenol-formaldehyde to blends containing 80 per cent retted pulp and 20 per cent chemical pulp, on the mechanical and optical properties of produced paper sheets was also studied.

Introduction

Newsprint paper is produced from 80-90 per cent mechanical soft wood pulp (high-yield pulp) and the rest is bleached kraft pulp. The high percentage of mechanical pulp in newsprint furnish enhances low production cost and good opacity which determine the quality of newsprint as a printing paper[1]. Crown Zellerbach Corporation (in Cooperation with Hawaiian Sugar Producer Association), produced mechanical bagasse pulp through a disk refining process. In this process the bagasse is reduced to a pulp consisting of very fine particles without the fibrous characteristics.

Technical difficulties arise in processing bagasse for mechanical pulp because it contains non-fibrous materials. Generally, non- fibrous materials and soluble solids are removed by retting operation. Retting is done either by submerging in ponds or rivers or in vats, where the temperature of the water can be controlled. Also, retting can be made with pure culture of bacteria as well as with chemical and enzymatic method[2]. Dew retting i.e., spreading the raw material out in the open space, exposing it to the action of dew and the sun is also used. Itt has been reported that pith loosened from the fibre bundles by retting operation due to the action of the micro-organism, which digested the parenchyma cell without damaging the fibre[3].

The aim of this work is to investigate the effect of different retting operations of bagasse to produce suitable high yield pulp for newsprint paper after blending with local chemical bagasse pulp. The effect of different additives on the properties of finished paper sheets are also considered.

Experimental

Preparation of High Yield Retted Pulps

The retted pulps were prepared by two retting operation, namely: water and acid retting. In water retting, bagasse samples were soaked under tap water at a liquor ratio of 1:15 for different time intervals (12 hrs, 1 day, 2 days, .., 7 days), at room temperature. However, in case of acid retting, different concentrations of sulfuric acid (0.5, 1 and 2 per cent of pulp were used, with the same experimental conditions. The *p*H value of the moist pulp was determined for every period, then washed with water several times till neutralization, followed by beating using Jokro beater at 6 per cent pulp consistency at a speed of 150 r.p.m. The °SR was measured according to German Standard Method.

Bagasse Chemical pulp

Unbleached bagasse chemical pulp used in newsprint furnish was provided by El-Nasr Company Edfo, Egypt.

Bleaching

Bleaching of retted pulps was carried out by two stages hydrogen peroxide method[4]. However, bleaching of chemical pulp was carried out by conventional three-stage method (chlorination - NaOH and hypo- chlorite).

Chemical Analysis

The raw material, retting and chemical pulps were chemically analyzed for lignin according to the institute method of paper chemistry, Appleton, Wisconsin Institute[5], pentosans according to Jayme and Sarten[6], and ash content was estimated gravimetrically. The data recorded were an average of three measurements.

Pulps Blending and Sheet Making

Bleached-retted pulp was mixed with different ratios of chemical pulp (both of 42°SR) and rebeaten together up to 50°SR in a Jokro mill beater at 6 per cent consistency and a speed of 150 r.p.m., then disintegrated for two minutes.

The paper sheets produced from the above blends were prepared according to the S.C.A. standard, using the model S.C.A. sheet former (AB Lorentzen and Wettre), followed by pressing and drying at 60°C for 2 hrs, using rotating drum.

Addition of Additives

In this study Kaolin, rosin or phenol formaldehyde resin was added with different ratios to blended pulp (80 per cent retted pulp and 20 per cent chemical pulp), to study the effect of each additive on the properties of finished paper sheets.

Mechanical and Optical Testing

Finished hand sheets were conditioned at 20°C and 65 per cent relative humidity, and tested for breaking length and tear factor as mechanical properties, also brightness and opacity were measured as optical properties.

Data Presentation

In order to express the rate of change a ratio "R' was developed which is presented as follows:

$$\text{Relative change "R"} = \frac{\text{Reading value}}{\text{Initial value}}$$

Results and Discussion

Beating and pH-value of Retted Pulp

In comparing the beatability of the acid pretreated samples with that of water retted samples, it is clear that, the former needed 45 minutes while the latter needed 30 minutes to achieve the same freeness (about 42°SR), as shown in Tables 1 and 2.

The better beatability of the water retted samples can be attributed to better swelling, thus a more loose fibre structure is produced which favoured fibrillation on beating. On the other hand the cellulose fibres exhibit on beating. On the other hand the cellulose fibres exhibit a marked resistance to hydrolysis by dilute acid at room temperature where the fibres become more stiff and brittle. Therefore, acid-pretreated fibres were to some extent broken and consequently it needed more beating time.

Variation in *p*H value, a negligible change was recorded owing to the high acidity of solution used in case of acid pretreatment. However, in case of water retting, a slight initial decrease in *p*H-value is detected in case of 12 hrs and 1 day soaked samples, than the *p*H-value tended to increase again up to the initial value after retting period of 7 days, as shown in Table 3.

The observed increase in acidity may be due to the natural presence of some polyglucuronic acids. Moreover, it is believed that partial oxidation of the residual sugar to glucuronic and galacturonic acids may occur during bagasse storage. At prolonged retting, growth of some micro-organisms may cause biochemical degradation of these acids to simple sugar on which they feed.The yield of all sample pulps was in the range of 88-95 per cent.

Chemical Analysis of Bleached Retted Pulps

The chemical analysis of all bleached retted pulps and alcohol benzene extracted bagasse raw material are shown in Table 4.

From Table 4 it is clear that retting process led to reduce the pentosan content compared to that of bagasse raw material, due to the alkalinity of the

Table 1 — °S R Measurements of water retted samples

Retting time / Beating time	12 hrs	1 day	2 days	3 days	4 days	5 days	6 days	7 days
15 min.	16	24	18	21	23	24	25	24
30 min.	31	40	43	40	41	34	36	40
45 min.	40	49	50	52	49	42	42	41
60 min.	40	51	—	—	49	49	48	48

Table 2 — °SR Measurements of sulfuric acid retted samples

Retting time	0.5 per cent				1 per cent				1.5 per cent			
Beating time (day)	1	3	5	7	1	3	5	7	1	3	5	7
10 min.	12	13	11	12	10	12	10	9	12	12	12	14
20 min.	22	24	22	22	21	23	24	20	25	24	22	22
30 min.	33	25	30	30	32	30	30	31	30	34	32	32
45 min.	39	34	37	42	36	42	42	38	39	37	40	42

Table 3 — pH value of water retted samples

Retting time	0	12 hrs	1 day	2 days	3 days	4 days	5 days	6days	7 days
pH-value	7.2	6.1	6.2	6.4	6.5	6.6	6.7	6.9	7.8

Table 4 — Chemical analysis of raw bagasse and retted pulps

Raw +retted pulps	Bagasse raw material	Water retting		Acid retting for 7 days		
Property		1 day	7 days	0.5%	1 %	2 %
Pentosan, %	23.80	19.18	17.52	13.46	12.26	11.40
Lignin, %	24.47	7.97	9.40	8.80	7.94	8.00
Ash, %	1.96	3.40	3.84	3.50	3.50	3.09

bleaching medium. Also, the reduction in hemicellulose in case of acid retting is more pronounced than the case of water retting as hemicellulose is much more susceptible to acid hydrolysis. The lignin content of water and acid retting are quite the same, i.e., having the same bleachability. It is clear also that, lignin content is more reduced compared to that of bagasse raw material, this attributed to high alkalinity of bleaching medium. However, the high ash content of all bleached pulps compared with unbleached bagasse is ascribed to silicate deposition in cell lumen[7] as a result of using sodium silicate in the bleaching liquor.

Blending Effect of Different Retting Pulps with Chemical Pulp on Properties of Produced Paper Sheets

Paper sheets were prepared from blends, containing different ratios (50, 60, 80 and 100 per cent) of bleached mechanical retted pulps (for 7 days, also 0.5, 1 and 2 per cent for 7 days in acid), with bleached chemical bagasse pulp.

Fig 1 presents the effect of blending ratio on the relative change in the mechanical properties (as breaking length and tear factor), and optical properties (as brightness and opacity) of produced paper, with reference to those of unblended pulp sheets.

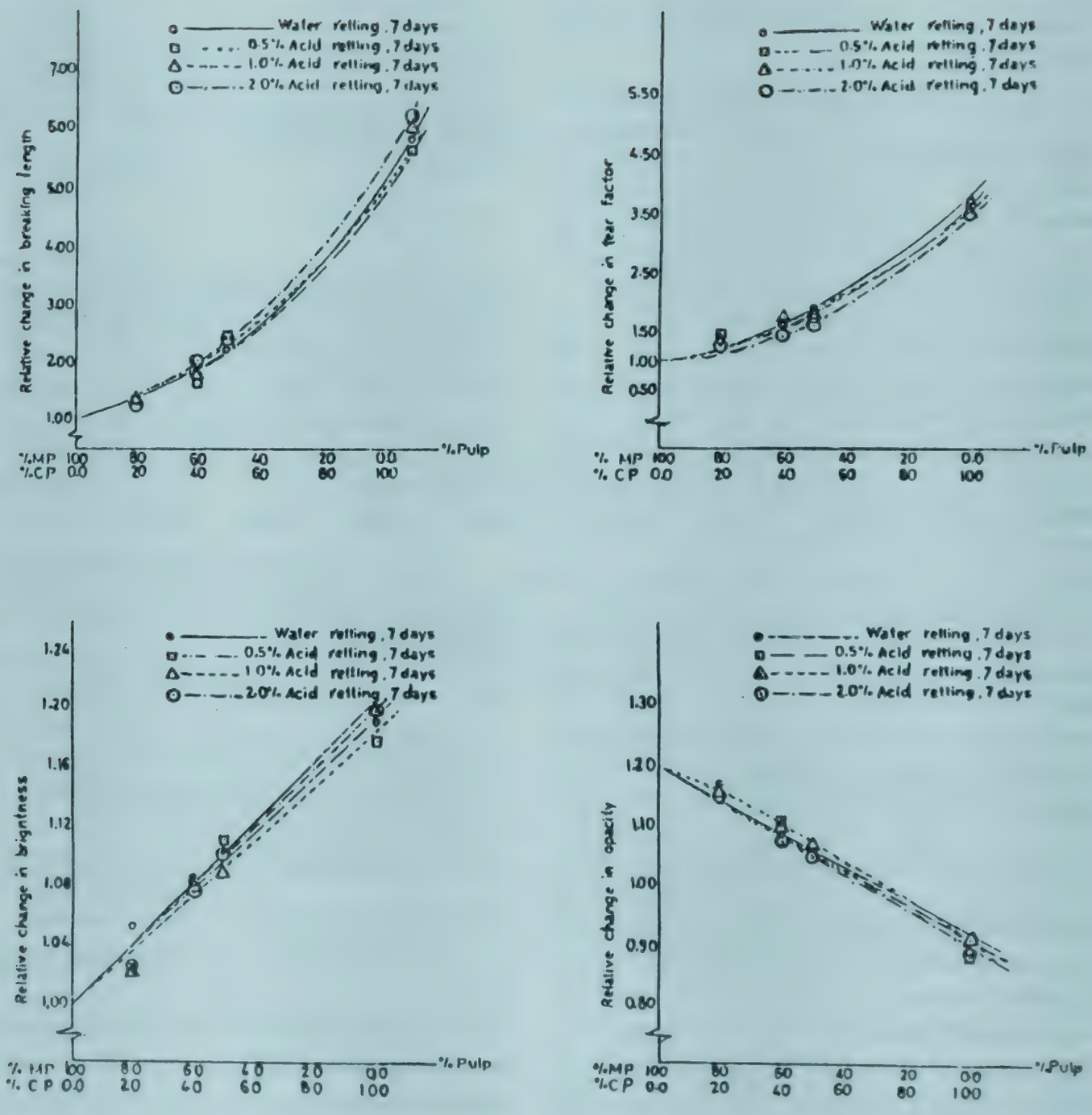
Water retting, 7 days
0.5% Acid retting, 7 days
1.0% Acid retting, 7 days
2.0% Acid retting, 7 days
Relative change in breaking length
Relative change in tear factor
Relative change in brightness
Relative change in opacity
% MP 100 80 60 40 20 0.0
% CP 0.0 20 40 60 80 100
% Pulp

Fig. 1 — Effect of pulp blending on mechanical and optical properties of paper

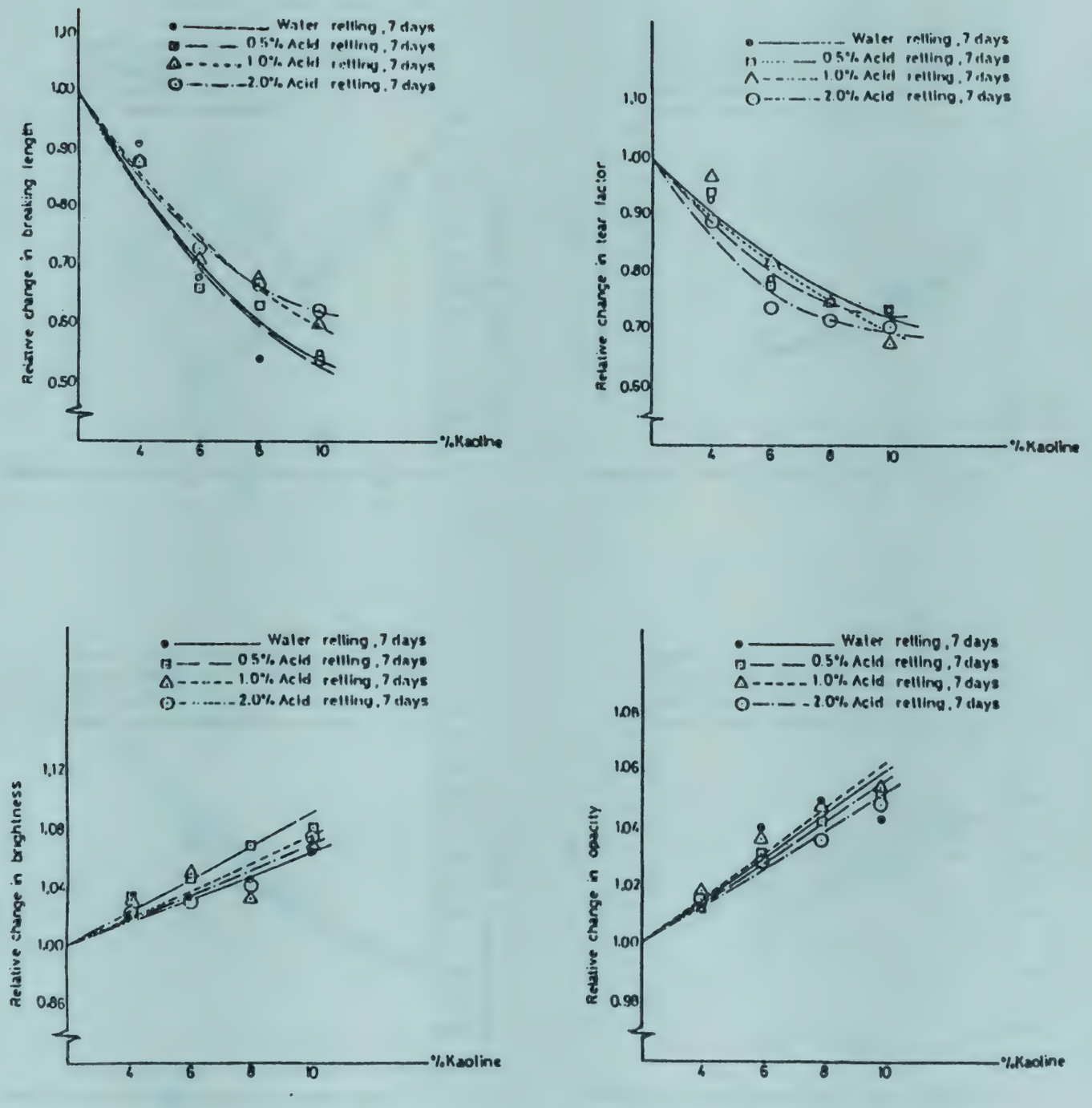
Water retting, 7 days
0.5% Acid retting, 7 days
1.0% Acid retting, 7 days
2.0% Acid retting, 7 days
Relative change in breaking length
Relative change in tear factor
Relative change in brightness
Relative change in opacity
%Kaoline

Fig. 2 — Effect of kaolin per cent on mechanical and optical properties of paper

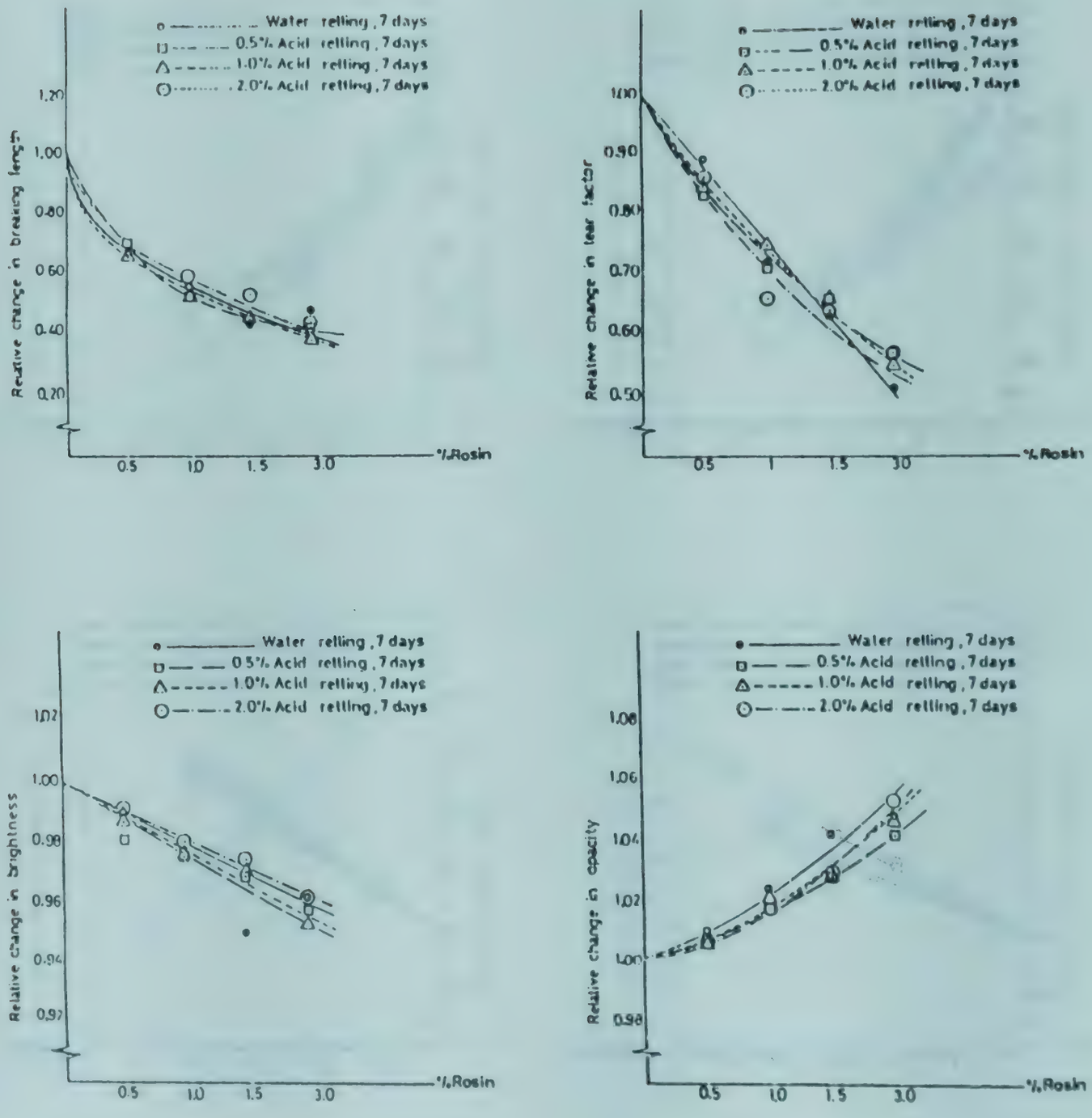

Fig. 3 — Effect of rosin per cent on mechanical and optical properties

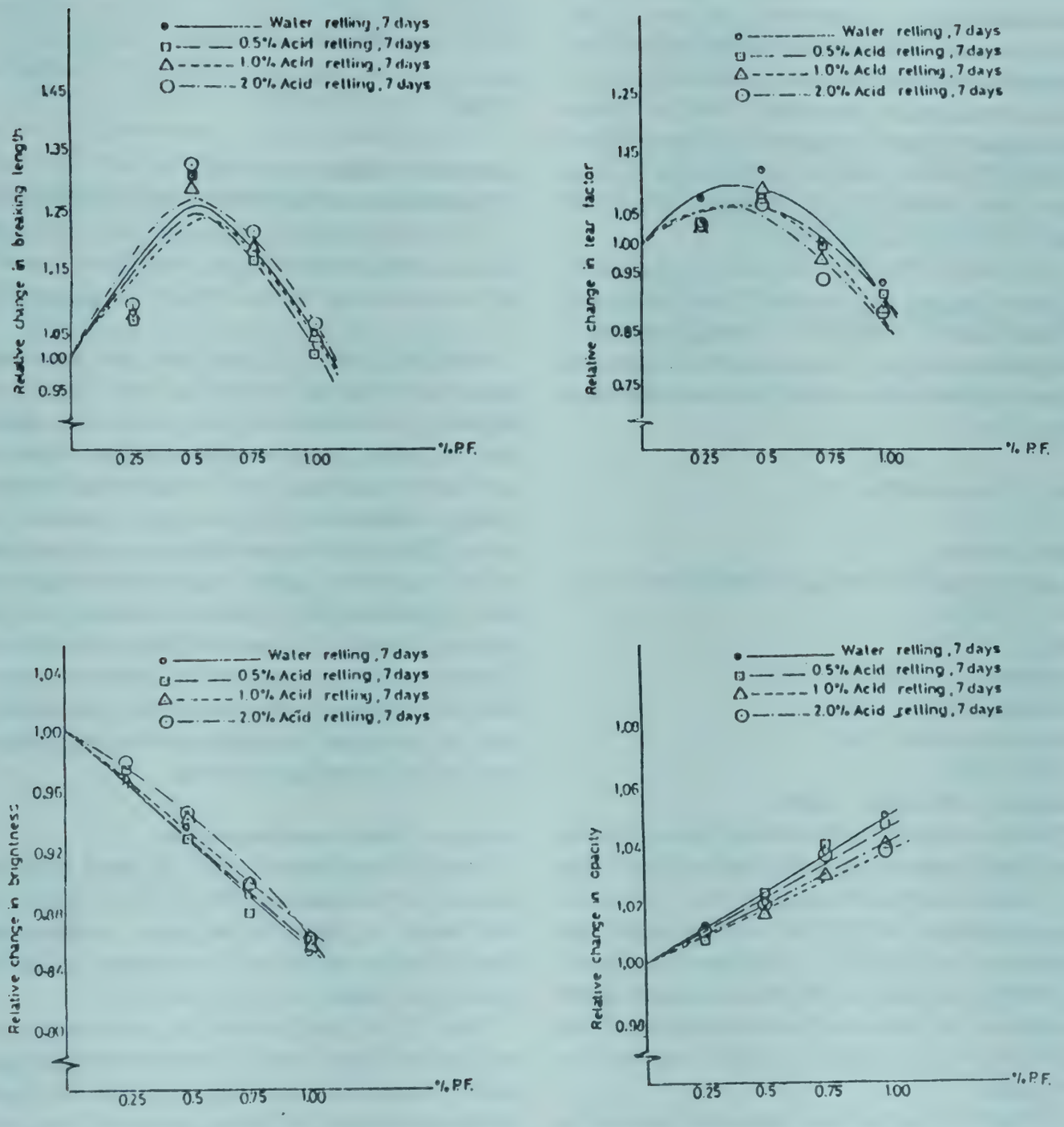

Fig. 4 — Effect of phenol formaldehyde resin per cent on mechanical and optical properties

It is clear that the mechanical and optical properties, except opacity, are improved by increasing the amount of chemical pulp, due to better strength and high brightness of chemical pulp in the blend. However, the opacity is decreased with decreasing fines in mechanical pulp, "retted pulp" (8), as high fine content enhances opacity by increasing light scattering. Moreover, one can note that the different mechanical retted pulps responded in similar manner towards blending with the chemical pulp, since there is insignificant difference between the relative change in the mechanical and optical properties of all blends at the same blending ratio.

It is clear also from Fig. 1 that blends containing 50% retted bagasse pulp are insufficient for producing paper sheets of comparable properties relative to the imported newsprint, but just fit with the minimum newsprint characteristics except for somewhat lower tearing factor.

Effect of Some Additives

Addition of Kaolin

Kaolin of the following specification was used.

Si_2 : 46.5 %

Al_2O_3: 39.5%

Brightness: not less than 90%

Combined water : <14%

Moisture content : 3%

Fe_2O_3: 0.6%

Screen: <200 mesh - 0.02%

The effect of addition of different ratios of kaolin in the blends bagasse mechanical pulps (from 1 day and 7 days, water retted bagasse, also 7 days acid pretreated samples) with 20 per cent bagasse chemical pulp are shown in Fig. 2. As shown in the figure, the strength properties of all produced paper sheets decreased as the amount of kaolin is increased. This significant loss in the paper strength is attributed to two reasons:

(1) Paper with and without kaolin are compared at the basis weight. Consequently, a sheet containing filler contains less fibre and is accordingly weaker.

(ii) The strength of paper is mainly due to fibre-fibre bonding. The kaolin particles occupy space between the fibres, and thus interfere with the fibre bonding. This led to an increased number of fibre-air and kaolin-air interfaces, which reduced the mechanical properties. On the other hand, the brightness and the opacity increased with increasing the kaolin percentage.

The above results are in good agreement with that reported by many investigators[9,10]

Also, the different pulps showed similar responses to kaolin addition. The relative change in brightness for all paper sheets varied within a limited range of about 1.2 - 3.5%, while that of opacity was about 0.4 - 1.4%.

Addition of Resin Size

The effect of adding different ratios of rosin (0.5, 1, 1.5 and 3 per cent) to the same above blend (80 per cent, retted mechanical pulp with 20 per cent with 20 per cent bagasse chemical pulp) are given in Fig 3.

From this figure, it is clear that, the mechanical properties (breaking length and tear factor) and brightness of all obtained paper sheets are deteriorated on adding rosin to the pulp, the degree of deterioration increased with increasing the rosin percentage whereas the opacity of paper sheets is improved. This deterioration effect of rosin size is due to the adsorption of cationic alum-rosin complex on anionic cellulose fibres, which interferes with the hydrogen bonding between the fibres and adversely affects the dry strength of the obtained paper, whereas the opacity is improved due to the action of alum in settling the fine fraction down, thus a tighter (less porous) sheets are obtained.

Addition of Phenol Formaldehyde Resin

Phenol-formaldehyde resin of resol type was added in different amounts (0.25, 05., 0.75 and 1 per cent based on pulp), to the same pre-mentioned blended bagasse pulps and the properties of the obtained paper sheets are shown in Fig. 1.

From Fig. 4, it is obvious that, addition of resol resin up to 0.5 per cent to the examined pulp gave papers of improved breaking length and tear factor. Further increase in the added amount of resol resin caused reduction in these properties. The improvement caused in strength properties is probably due to the regular distribution of this small amount of resin within the fibres and fines fraction. Thus, a cross linkage reaction which involves cross-linking within the fibre structure itself is developed leading to creation of covalent bonds with the cellulose present in the fibres. On the other hand, increasing the amount

of resin enhances homopolymerization of the resol resin and the cross-linked resin network thus formed between the fibres weakens and dissipates the inter-fibre bonding. So the paper loses its strength.

Also, the brightness of all produced papers is reduced, whereas the opacity is improved by addition of phenol formaldehyde.

As shown in Fig. 4, the relative chance in all paper properties by addition of resol resin differs from one pulp to the other within a narrow range as a result of quite similar response to phenol formaldehyde addition.

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Mesquite Gum (*Prosopis juliflora*) : Potential Binder in Tablet Dosage Forms*

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Use of mesquite gum in tablet formulation by direct compression and wet granulation method has been evaluated. Binding property of mesquite gum has been compared with the commercially used *Acacia* and *Tragacanth* gums. Tablets were prepared using 2 to 12 per cent increasing concentrations of mesquite gum. The effect of concentration on extent of binding has been evaluated by the parameters of weight variation, hardness, per cent friability and disintegration time of tablets prepared. Granule properties like particle size distribution, bulk density, per cent compressibility, angle of repose etc. were studied. Suspensions were prepared in 2 to 20 per cent solution of mesquite gum and their stability and sedimentation behaviour was studied to evaluate suspending property.

Introduction

Industrial gums, which for the most part are water-soluble polysaccharides, have enormously large and broad applications in both food and non-food industries. All applications depend on the properties provided by large molecules in various states of hydration, but mostly depend on the properties they impart to solutions and gels. Polysaccharides are used in the food industry due to wide availability, low cost, and nontoxicity. Their use in non-food applications depends on unique physicochemical properties they provide, often at costs below those of synthetic polymers.

They are frequently used in pharmaceutics as thickening, binding, emulsifying, suspending and stabilizing agents. As binders they impart adhesive qualities to powder material by formulation of granules of desired size, hardness, strength, disintegration and compressibility. Various gums such as *Acacia*, *Tragacanth* have been used as binders for the manufacture of tablets. In view of the importance of binders in pharmaceuticals for the manufacture of tablets, mesquite gum was undertaken to evaluate the binding properties through assessment of various parameters essential for pharmaceutical applications.

Mesquite gum is produced by the nitrogen-fixing desert shrub *Prosopis*[1], from the same botanical family as the *Acacia* species which yield gum arabic. Mesquite gum is used in domestic cooking in the Sonora region, Mexico, to prepare a traditional desert known as 'capriotada', but approval as a commercial food additive is unlikely, because of the high content of tannic compounds[2]. The main current uses of mesquite gum are in the ink, textile and glue industries. In view of the rising cost of gum arabic, coupled with limitations and variability of supply[3,4], mesquite gum may become an increasing important alternative in such non- food applications[5].

Both mesquite and *Acacia* show striking similarities in primary structure. Both appear to have 'core' of β-D- galactose residues, comprising a (1 → 3) linked backbone with (1 → 6) linked branches, bearing L- arabinose (pyranose and furanose ring forms), L-rhamnose, β-D-glucuronate and 4-O-methyl-β-D-glucuronate as single sugar or oligosaccharide side chains[6-12]. Comparison of rheology of mesquite gum with that of gum arabic over the full range of concentrations have shown that intrinsic viscosity of mesquite gum ($[\eta] \approx 0.11$ dl g^{-1}) was appreciably lower

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than that of gum arabic ($[\eta] \approx 0.198$ dl g^{-1} in 0.1M NaCl at 20°C and was independent of ionic strength above $I \approx 0.05$, indicating a compact structure capable of only limited contraction. Departures from dilute-solution behaviour ($\eta \approx C^{1.4}$), occurred at $C[\eta] \geq 1$ for both materials, with a progressive increase in a concentration dependence at higher space-occupancy, behaviour typical of soft, deformable particles, rather than interpenetrating molecules. The increase in viscosity with concentration was steeper for mesquite, consistent with evidence from size-exclusion chromatography and light scattering that the larger (and presumably more deformable), wattle 'blossom' component of gum arabic was absent from the mesquite gum[13].

Gum tragacanth is only partially soluble in water, and the soluble portion consists of a mixture of polysaccharides in association with a glycoside of unknown structure. Fractionation of the gum gives as the major component tragacanthic acid[14-17], and as the minor component a highly branched L-arabino-D- galactan[18,19]. Tragacanthic acid has the approximate composition, D-galacturonic acid (43%), D-xylose (40%), L-fucose (10%) and D- galactose (4%) with D-glucuronic acid, L-rhamnose and L-arabinose as trace constituents. The main chain of polysaccharide approaches most closely to that of a galacturonan of the pectic acid type, with the very frequent incursion of L-rhamnose residues[20].

Mesquite gum (*P. juliflora*) is available in sufficient quantity in the states of Gujarat and Rajasthan of India which has prompted us to undertake this investigation. Binding properties of mesquite gum through assessment of various parameters essential for pharmaceutical formulation was undertaken. This study includes the study of suspending, binding and other properties of this gum and comparison has been made with gum arabic and gum tragacanth.

Materials and Methods

Mesquite gum was received from Gujarat State Forest Corporation. It was dissolved in water (50%, w/v), with constant stirring. It was centrifuged and centrifugate was cooled to freeze in acetone (−55°C). The freezed gum was lyophilized (−30°C) to creamy gum powder (yield ~ 90%) using Christ lyophilizer (Germany). Tablets were prepared in a Korsch single punch tabletting machine. Friability and hardness of tablets were determined by friability test apparatus IEC, Bombay and Monsanto hardness tester respectively. Tablet disintegration time was observed in tablet disintegration machine (USP model) IEC, Bombay. Diameter and thickness of tablets were determined with the help of a screw gauge to get the surface area of tablets.

Evaluation of Binding Properties

Direct Compression – Lactose tablets of 300 mg containing 2, 4, 8 and 12 per cent of mesquite gum and 1 per cent magnesium stearate as lubricant were prepared by direct compression method in a single stroke. Tablets of 300 mg lactose using 2 per cent Gum Acacia and Gum Tragacanth were also prepared for comparison. Physical properties like weight variation, surface area, friability, hardness and disintegration time[21] were evaluated.

Wet Granulation — 10 per cent solution of mesquite gum and *Acacia* gum were prepared. 30 ml of these solutions were added to 100 g of lactose and kneaded separately. The wet mass is passed through sieve no. 18 and dried at 60°C.

The granules were subjected to particle size determination. Three particle size fractions were obtained i.e. <850 μ, 250 to 850 μ and >250 μ size corresponding to 51.27, 45.56 and 3.17 per cent of mesquite gum and 72.97, 25.62 and 1.40 per cent of *Acacia* gum. Each particle size fraction obtained for each binder was subjected to bulk density, per cent compressibility and the flow properties determination. The bulk density and per cent compressibility was determined by 3-tap method[22]. The angle of repose was calculated by using fixed funnel method[23].

The granules were lubricated with 1 per cent magnesium stearate and punched into 300 mg tablets and the physical properties of tablets as described in direct compression were evaluated.

Evaluation of Suspension Properties of Mesquite Gum

Suspending properties of different concentrations of mesquite gum were evaluated using ZnO as suspending particles in the ratio of 2:10 (w/v) and 3:10 (v/v). Paste of suspending particle (ZnO) and suspending vehicle was prepared in mortar and pestle by trituration. After proper mixing suspensions were

transferred to 10 ml stoppered measuring cylinder and allowed to stand. Volumes of settlement with reference to time were recorded and comparison was made with gum *Acacia*.

Results and Discussion

Binding property of mesquite gum of tablet formulation prepared by direct compression was studied and comparison was made with gum *Acacia* and gum *Tragacanth*. It was found that there was no significant difference in the weight variation and surface area of tablets in all the cases. Mesquite gum yielded tablets of higher hardness of 5.4 ± 0.335 kg/cm^2 with per cent CV 6.19 as compared to gum *Acacia* 4.86 ± 0.359 kg/cm^2 and to gum *Tragacanth* 3.99 ± 0.581 kg/cm^2 with per cent CV of 7.38 in both the cases. As regards to the disintegration time of the tablets it was 7.8 minutes in mesquite gum and 4.5 minute and 3.5 minute in *Acacia* and *Tragacanth* gum respectively. The per centage friability of tablets with mesquite gum was found to be 0.67 which is equal to that of gum *Acacia* and in case of *Tragacanth* gum it was 0.73. Disintegration time of the tablets were concentration dependent and they increase by increasing the per centage of mesquite gum. No marked change in per centage friability, hardness, surface area and weight variation of the tablets was observed with increasing concentrations (2% to 12%) of mesquite gum.

The granule properties like bulk density, per cent compressibility, angle of repose etc., of granules prepared with mesquite gum were found to be similar to those with Acacia gum. The properties of tablets prepared with above granules were evaluated for the parameters mentioned for direct compression and were found to be at par with gum Acacia.

The suspending property of mesquite gum revealed that suspension behaviour of 2 per cent mesquite gum was comparable to that of 2 per cent Acacia gum. An increase in the per centage of mesquite gum (2 to 20%) increased the stability of suspensions. Results indicate that mesquite gum forms a quite good and stable suspension better than that of the Tragacanth gum and equally good to that of the commercially used Acacia gum.

On the basis of evaluation of binding and suspending properties of mesquite gum it can be concluded that it can be effectively used in pharmaceutical formulations like other natural gums.

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BOOK REVIEWS

Management, Marketing and the Competitive Process, edited by Peter E Earl (Edward Elgar Publishing, Cheltenham, UK) 1996, pp 395 +xxi, Price: £ 49.95
[ISBN 1 85898 494 3]

The book under review deals with various aspects of business strategy with an interdisciplinary approach. The book comprises 15 chapters, which together give the necessary exposure to the issue from an interdisciplinary perspective. In the present context of globalisation, competition and the industrial strategy are the most debated issues. Several issues come up like, what is the behavioral perspective of business strategy? What makes competing firms to go for strategic alliance? How strategic decisions are made? The complex nature of these issues requires an interdisciplinary approaches to develop an understanding. In this book, an attempt has been made to present the limitations and strengths of various disciplinary approaches to the problem. It stimulates the thought process in understanding what actually business management is. Both theoretical and empirical evidences are presented to strengthen the arguments put forward by the authors.

The common element in all the articles is a departure from a static equilibrium condition for competition to a dynamic setting. The book begins with an introduction by Peter E Earl, followed by John Nightingales enlightening article, where he has very meticulously dealt with competition and firm in the evolutionary framework, a deviation from neoclassical framework of equilibrium state. The growth of firm and market behavior are seen as dynamic processes. Here, firm is shown to evolve over time through a process of continuous interaction. Competition is seen in terms of different firms' abilities to maintain difference from their competitors in terms of variation in their capability to access and to put to use the resources differently. At this juncture, Robertsons critical review of business history studies adds a new dimension to the perception of competition, firm and industrial growth, different from the neoclassical price competition. It gives an opportunity for researchers to probe further whether it is the market failure or the organisational success that leads to vertical integration. Brian J Loasby's paper is an interesting empirical study on Du-Pont having theoretical implications. He has brought out the issue on, how the firm through its ability to access, process and organise information in different way, could innovate and thus have a competitive position in the market. This is an important contribution to the theoretical debate on market coordinated vs organisation coordinated enterprises, very elaborately discussed by Lazonick in his book on 'Business Organisation and the Myth of the Market Economy'.

At this point, Neil M Kays critical review of schumpeters model of competition from the Business Policy perspective, brings out the inadequacy of Schumpeterian model, in dealing with the complexity of the present day industrial structure. According to him, complex interaction of multiple product and multiple technologies cannot be explained by using simple product market structure of Schumpeter. The author advocates need for Schumpterian research programme to include both internal market in the diversified firm and also the external markets in finance and technology, to deal with the problem of complexity of business competition.

This has an important implication for understanding strategic alliances and competition in a complex network. This complexity has been dealt by Glaister, where he has presented both the resource-based view of strategic alliance and Williamsons transaction cost approach and tried to bring out the difference at the conceptual level, by saying that Williamsons focus is an cost minimization whereas, the resource based view emphasises on Ricardian rent. Both are within the framework of market coordinated approach. There is an altogether a different perspective to it in the contemporary research on business organisation, where the strategic alliances are seen in the light of the resource creation or

utilization ability of the partners, within the framework of organisational coordinated approach.

There are three interesting cases by Earl, Zwart and Inge Furseth, which talk about formal and informal alliances. What emerges from the case study which Earl has presented is that, it is not the transaction costs and opportunistic behavior which result in internalization of market but it is rather an arrangement that works on the basis of cooperation and direction. This also reflects how these things are beyond market transaction. Zwart again through the example of food industry has dealt with the other end of the innovation chain, to arrive at the conclusion that the market is internalized through cooperation or network mode. The supply firms' relationship with retailers is the forward linkage. Inge Furseth has shown how through selective distribution of brands and labels, entry to barriers is created and not through price competition. What emerges is that the retailers do not mainly compete on price. Here, it is the development of brand name and then targetting the client group through segmentation, which has been maintained by these retailers for competitive edge. All the three articles broadly focus on the aspect of coordination, where it is not the price competition or the transaction cost or the opportunistic behavior but it is the mode of organisational linkages for competition

Another important aspect of business strategy, the pricing policy has been dealt by Langlois, by taking the examples of the US and Japan automatics, the US canners and the US meat and poultry producers, to show that temporal factors are taken into consideration, for arriving at certain price fixation and it is more of a managerial prerogative rather than something thrust upon firm by the market. Behavioral aspect of pricing is dealt by Downward, by using cybernetics as the theoretical framework. Here for understanding the behavioral aspect of pricing the author has shown how the system uses information, processes it, and then communicates the same, vis-à-vis the environment. The focus is on the organisation where, depending upon whether it is a "mechanistic" or 'organic' organisation, the decision making is rigid or flexible. The important issue which the author has brought out is, it is the organisational learning and interaction which determines the pricing policy of a firm. The economic agents, as assumed in the neoclassical framework are not without attributes. So, the firm's response to demand and supply stocks is a part of organisational behavioural aspect. The behavioral aspect of business organisation has been dealt by Harper and Earl, as knowledge created within the people, and takes a shape, depending upon their ability to articulate. It is not something coming from outside. According to this, any change in the environment can be interpreted differently by two different managers. Here, the emphasis is more on cognition and learning. In this chapter, the authors have proposed a further theoretical development of the growth of knowledge approach for understanding business behavior. This is an important contribution, especially in the present context of organisation it studies via-a-vis the bounded rationality.

Sharp and Dawns have presented a critique Porter's typology of cost leadership, product differentiation, and focus for firms to be competitive. Like the resource base theory they also hold the view that a strategy which through distinctive difference in resource and ways of doing things can generate higher profitability in which case it is difficult for the firms to imitate. The critique is again within the market coordinated framework. This paper gives an insight into the limitations of Porter's typology for understanding the business strategy.

Beckett's article should have been in the beginning of the book, as he has introduced at length the relevance of strategic management as a discipline in understanding business strategy. The author has presented the underlying principles behind strategy and the essentially assumption to arrive at a strategy. This is an important contribution especially in the present context of business management where strategy has a definite meaning. Following this is an important contribution by Singer, who has presented the conceptual framework for understanding Strategy as rationality. What has been focused is the diverse elements of a group or set which come together in the form of strategic alliance. The essence being to have a synergy of different views of rationality and optimality, so that economic development goes along with sustainability and equity. In the present context, when so much is talked about strategy, this adds an important dimension to it where one should think of strategies which have the societal dimension to it as well.

It is a resourceful and timely book comprising exhaustive bibliography on business history, organisation studies, innovation, and competition. It has dealt with a very complex issue with clear orientation and perspective. This book will be of interest to researchers of business organisation studies, innovation management, and industrial economics.

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Controlling Pollution — Incentives and Regulations, by Shekhar Mehta, Sudipto Mundle and U Sankar (Sage Publications India Pvt Ltd, New Delhi) 1997, pp153, Price: Rs 250 (cloth) [ISBN 81 7036 5937]

Today, one of the main problems that India as well as the world is facing , is the environmental degradation. Even though this is not a new problem, yet in the past few decades there has been a rapid change in man's activities which has resulted in a steady deterioration of the environment. Hence the importance of prevention and control of environmental pollution has been the subject in limelight. The Indian government has also recognised the problem and as a step towards controlling it, imposed certain laws and regulations. The authors have very well taken up this subject matter dealing mainly with regulations imposed by the Government of India for the water and air quality and the incentives upon violation.

The authors start with 'The Status of Pollution and Pollution Control in India'. Here, the existing Water and Air (Prevention and Control of Pollution) Acts, their enforcement, and the fiscal incentives for pollution control are dealt with. Also, trends in air and water quality and the impact of regulation is nicely described with the help of tables. Pollution control equipment with depreciation allowances and rebate from customs and/or excise duty are listed.

The second chapter on 'Policy Instruments for Pollution Control' discusses the choice of instruments dealing with various criteria like static and dynamic efficiency, administrative convenience, revenue, etc. The authors are of the opinion that not a single instrument can dominate others. The authors here suggest four options of the incentive based regimes, the government having to play varying roles in pollution abatement: (i) Abatement charges with government clean up, (ii) Abatement charges with third party clean up, (iii) A tax subsidy scheme, and (iv) Tradable private permit system.

In the third chapter on 'Economic Incentives and the Cost of Abatement: The Case of Waste Water Treatment', the authors discuss the result of an illustrative study taken up for analyzing the cost of cleaning up waste water. Various tables and graphs depicted have made the elaborated study simple and concise.

Finally, the authors have again dealt with the four options of incentive based regime bringing out its limitations. They conclude with suggestions for further research on many other related topics to be done for the effective pollution control measures in India.

A systematic study has been done here with the help of NIPFP and NEERI and emphasis has been on difficulties in: (i) selection of instruments, (ii) implementation, and (iii) formulation of policy, which will be of particular interest to the students of Environmental Science, Environmental Economics, and Environmental Management. This book will also be of interest to the policy makers.

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Advances in Photosynthesis (Series Editor, Govindjee) Vol. 4 —Oxygenic Photosynthesis: The Light Reactions, edited by D R Ort and C F Yocum (Kluwer Academic Publishers, Dordrecht, the Netherlands) 1996, pp 682, Price: $150.00 (pb) L[ISBN 0 7923 3683 6 (hb); 0 7923 3684 4 (pb)]

The volume on "Oxygenic Photosynthesis: The Light Reactions" is the fourth in the series on Advances in Photosynthesis, published by Kluwer Academic Publishers, the Netherlands. The first volume on "Molecular Biology of Cyanobacteria" [*see J Sci Ind Res*, **55** (1996) pp 763-764] was highly praised by the readers as it filled a long felt void. The subsequent two volumes in the series namely "Anoxygenic Photosynthetic Bacteria" and "Biophysical Techniques in Photosynthesis", have also been published and have received wide acclaim.

"Oxygenic Photosynthesis: The Light Reactions" represents the heart of photosynthesis research. The two distinguished editors, Drs D R Ort and C F

Yocum have done an excellent job of obtaining state-of-the-art reviews from internationally known contributors. Thirty-four chapters contributed by 57 authors encompass all aspects of electron transport and energy transduction processes in oxygenic photosynthetic organisms. These include thylakoid membrane structure, synthesis and assembly of the photosynthetic apparatus, the electron transport carriers, components, kinetics, and their regulations. Also, there are four chapters dealing with structure, catalytic mechanisms and regulation chloroplast ATP synthase. The readers will also find reviews on the light harvesting complexes of algae, gymnosperms and angiosperms as well as molecular biology and genetics of photosynthetic apparatus, regulation in expression of genes encoding proteins required in light reactions, and a chapter on plastid evolution. The insight into the structure-functional relationship in photosynthetic apparatus in oxygenic photosynthetic systems is now available at molecular details, and this volume illustrates it very vividly.

Overall, the book provides its readers with exhaustive up-to-date state-of-the-art report on photosynthetic apparatus that carries light reactions evolving oxygen. The graphical presentation of various chapters by the authors with excellent reproduction of figures and cartoons makes the book very attractive for post- graduate students in courses on Cell Biology, Biochemistry and Biotechnology. The references are selective, covering literature up to 1995. These features make the book an essential reference for the researchers. However, the book is quite expensive, but fortunately paperback edition is also available.

Photosynthesis research is progressing exponentially. One may have a doubt that such books will soon be outdated, but this reviewer feels that the book under review shall remain useful for long. The editors, Drs D R Ort and C F Yocum (and Iris Heichel) deserve applause for doing an outstanding job and Kluwer Academic Publishers for their excellent production. I recommend the libraries of our colleges and Universities to have a copy of this volume of the series on "Advances in Photosynthesis, and suggest that if you are interested in photosynthesis, do buy a paperback edition for your personal library.

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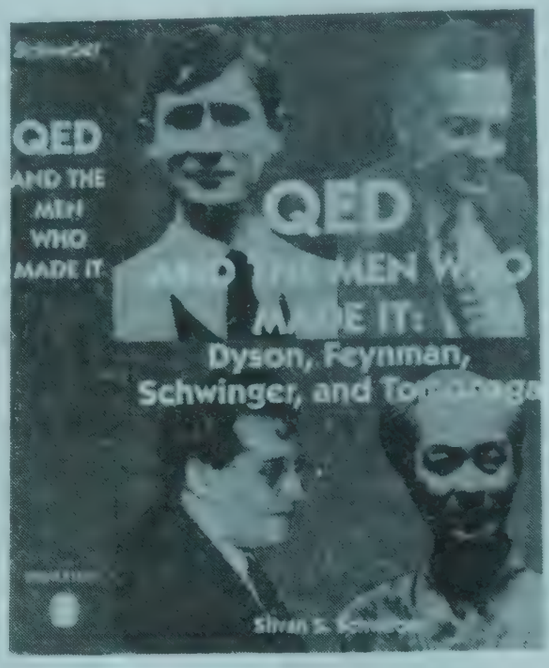
QED and the Men Who Made It: Dyson, Feynman, Schwinger and Tomonaga, by Silvan S Schweber (Princeton University Press, USA) pp xvii +732, Price $ 39.50 (pb)
[ISBN 0 691 03327 7]



Quantum Electrodynamics (QED) is widely recognized as the "Jewel of Physics", a name given to it by the celebrated Richard Feynman, who called it our "product possession". This epithet, is not only because the predictions of the theory have been found to be correct to an amazing degree of accuracy but also because the theory has served as the benchmark against all the other theories of elementary interactions compared. But like all other successful theories in physics, it did neither develop apriori nor was it the work of one single individual who sat down to work out the theory one day. Instead, it was the culmination of several decades of work by some of the finest human intellects of this century. And of course, with it come many anecdotes and a whole narrative.

What is QED? One of the finest descriptions of what the theory is and its import comes from Freeman Dyson, one of the key actors in the development of QED. Dyson calls it ".. the theory which brought order and harmony into the vast middle ground of physics", the middle ground excluding gravity and nuclear forces, but including the laws of atomic structure, solid state physics, lasers, optical spectroscopy and all of electronics. He goes on to add that "QED unifies all these diverse phenomena into a

small number of principles of great generality and elegance, weaving together special relativity and quantum mechanics into a seamless fabric".

By 1927, quantum mechanics was well established as the theory which correctly explained phenomenon within its realm of validity. This realm was governed by a fundamental constant of nature, viz. Planck's constant h. Any system whose characteristic mass (m), length (l) and time (t) were such that ml^2/t was of order h and l/t was much smaller than c, the velocity of light, could be satisfactorily explained by the quantum mechanics of Heisenberg, Schrodinger and Dirac. What remained, however, was the problem of "fitting of the theory with relativity ideas" to paraphrase Dirac's famous assertion. This was to preoccupy theoretical physicists for many years to come.

The first step towards this integration was in the form of Hole theory of Dirac. This was revolutionary because it entailed the creation and annihilation of matter as an intrinsic feature. Thus, vacuum became a physical medium in which electron-positron pairs are being constantly created and annihilated. The development of relativistic quantum mechanics in the 1930s can be seen as developing from two viewpoints. One was that of Dirac which took particles as fundamental entities while the other was the view which saw particles as quanta of fields which are fundamental. The quantum theory of fields, which was developed by de Broglie, Schrodinger, Jordan, Pauli and Heisenberg, was much richer in its potential than the particle approach, though both were essentially equivalent. The field theoretic approach was further bolstered by Fermi's theory of β-decay and Yukawa's theory of nuclear forces, both of which suggested that the domain of applicability of field theory possibly included weak and strong nuclear forces.

Nevertheless, the hole theory, though beset with problems of ambiguity when it came to multi-electron systems was also fairly successful. In fact, most of the predictions of QED during this period came from hole-theoretic calculations. These included bremsstrahlung, Compton effect, and cross-sections for electron- positron pair production and annihilation.

The successes of both these approaches were short lived; it was soon realised by the "founding fathers' that there were overwhelming difficulties when one did higher order calculations with the theory. The problem was of divergences or infinities in the calculation of certain physical quantities. These difficulties were sought to be overcome by various proposals which included the λ limiting procedure of Wentzel, the C-meson field of Sakata, the procedure of redefining the charge current operator in the vacuum polarization so as to absorb the divergence and the redefinition of mass and charge parameter to remove the infinities. All these ideas however were unsatisfactory and thus the situation in the 1930s and early forties was one of pessimism. The difficulties seemed insurmountable and this was an impediment to progress in the field and gave rise to an overall sense of gloom in the community.

The successful handling of the infinities came in the period 1945-50 principally due to the work of Kramers, Schwinger, Dyson, Feynman, Bethe and Tomonaga. Each of these individuals contributed significantly to the solution of the problems and placed the theory on a firm footing. Schwinger and Tomonaga developed a field theoretic formalism which identified and eliminated the divergences in a fully consistent, relativistic and gauge invariant fashion. This was essentially done by absorbing the divergent contributions into a redefinition of mass and charge parameters of the theory, an idea first suggested by Kramers. The formalism was elegant, self-consistent and most importantly made predictions regarding phenomenon like Lamb shift, magnetic moment of the electron, etc.

For instance, Bethe in 1947, explained the principal part of the Lamb shift to be around 1040 MHz using Kramer's renormalization ideas; however, Schwinger, Tomonaga, and Feynman obtained better results in QED through refined values of $\delta m/m$, or equivalently slightly different values of self energy as obtained by Schwinger, Weisskopf, and Feynman. These differences are reflected in values of the Lamb shift computed. Lot of pages are devoted to the multifaceted achievements of two stalwart of QED, viz. Schwinger and Feynman. The former being a rigorous field theorist and the latter renowned for his populist and pedestrian approach. Feynman is well known for his diagrams which have become synony-

mous with calculations in field theory. Schwinger, on the other hand worked with obscure and abstruse mathematics as evidenced in his three monumental papers, QED I-III. Schweber points out extensively the criticism of Wentzel and Pauli (pp 345-352) but that does not belittle Schwinger's contribution to the development of QED.

Feynman, true to his idiosyncratic personality, followed a totally different approach. His method was more akin to Dirac where particles were taken as fundamental and phenomenon understood in terms of the space-time trajectories of these particles. This unconventional approach, resulted in an extremely efficient computational scheme which is all prevalent in the field ever since. It was left to Dyson to show that Feynman's approach could be derived from that of Schwinger and Tomonaga and the mass and charge renormalization (redefinition) removed infinities from the theory to all orders of perturbation theory. The scheme of removing divergences, called renormalization theory, has played a central role in particle physics since then. The success of quantum electrodynamics together with the rules for renormalization was stupendous. It yielded values for quantities like the hyperfine structure of hydrogen or the magnetic moment of the electron which was in an unprecedented agreement with the experimental results. As an example of this unprecedented precision, Schweber mentions (pp 206) that best measured value of electron's g-factor by Dehmelt *et al.* as $g/2 = 1.001\ 159\ 652\ 193\ (4)$ agrees closely with QED which gives a value of 1.001 159 652 459 (135).

Silvan S Schweber, a distinguished physicist and the author of an excellent text book on relativistic quantum field theory, has donned the robes of a historian of science. And he has chosen to delve into one of the most exciting and intellectually fruitful period of science in this century. The book can essentially be divided into two parts. The first part deals with the development of the theory itself starting with the birth of quantum field theory. The various streams of the theory are described very clearly. The history of the ideas, the seminal conferences held at Shelter Island, Pocono and Oldstone, the various conflicting positions taken by the principal actors and interesting personal asides make wonderful reading.

What is remarkable about Schweber's work is that even though it is a work on history of science, he has steered clear of casting his book into any of the accepted moulds. It is easy, as he himself admits in the preface, to think of the history of QED fitting into both the Kuhnian mould or that of Lakatos. The Kuhnian notion of paradigm as a set of shared values (shared by a set of core workers) which determine the shape of the discipline, is easily substantiated by many examples from the history of QED. The whole program of renormalization could easily constitute a Kuhnian revolution. Afterall, ever since the success of renormalization in QED, it has been the cornerstone against which all contending theories of particle physics are measured. In fact, the "final" acceptance of the currently accepted gauge theories of strong and electroweak interactions, the so called Standard Model, was finally accepted only after *t* Hooft proved their renormalizability in the early seventies. Likewise, the Lakatosian notion of competing modes of knowledge is evidently the particle and the field theoretic approach. But it is to Swchweber's credit that he has stayed clear of these preconceived straightjackets. He is, as he says, interested in telling the story. And he certainly has done a wonderful job of it, especially in the second part of the book.

The second part of the book deals with "The men who made it". Here the author describes the life and work of the principal actors in the play, viz. Freeman Dyson. Richard Feynman, Julian Schwinger and Sinitiro Tomonaga. Devoting a full chapter to each of these remarkable men, Schweber weaves an excellent story of how they carried out their work. Based on innumerable interviews with the scientists and their collaborators, as well as many primary sources, he tells a wonderful tale of how real science is done. The specific character traits of the men and how these got reflected in their style of work, the post war milieu in particle physics, personal details of the scientists, it all adds up to a heady mix of an immensely readable account.

The book is a masterpiece. With many notes (thankfully assembled at the end), an extensive bibliography, and an eye for detail, Schweber has produced a narrative which will remain unmatched for some time to come. The only quibble one may have

is on some occasions, he has gone into too much, seemingly irrelevant details.

Silvan S Schweber has spent the last 20y researching for this book. And it shows in the thoroughness with which he has explored the subject. For a long time, history of science was a domain almost exclusively meant for the social scientists. Schweber has shown that not only can a practicing scientist do an excellent job of it, but in some cases may even be better equipped to do history of science since s/he is acquainted with the inner dynamics of the working of the field. It is now up to other eminent scientists to take up the challenge from where Schweber has left it.

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SCI-TECH UPDATE

Computer program removes speech impediments

Researchers at the University College London (UCL) have unveiled a computer program that allows speech problems in children to be analysed more accurately.

The method is more effective than the human ear at picking genuine dysfluencies and can provide an objective assessment when passages recorded before and after treatment are compared.

For example, the program can identify the start of each word in a recording of the child reading a passage of text, identify different problems such as the repetition of a consonant or the prolongation of an initial consonant sound. It can even pick out sequences where the child has stumbled upon a particular word and substituted a synonym instead.

It is intended to distribute the software to speech therapists in Britain and overseas so that the system can be evaluated and improved.

For further details, contact:

Department of Psychology, University College London, Public Relations, External Affairs, Gower Street, London WC1E6BT, United Kingdom, Tel: 171 380 7566. ❑

HKK

HP introduces LED lamps for outdoor applications

Traffic lights presently used mostly consist of incandescent lamps. Hewlett Packard is introducing high-brightness LEDs to replace the incandescent lamps that make them superior by virtue of their weather resistance, high brightness, and radiation pattern.

The lamps are guaranteed for six years and possibly have a life of one decade. Thus the maintenance costs are much below compared to the conventional traffic lights which are generally replaced every year. The other advantage that LED lamps offer is their Low power consumption, cutting down the operating costs. Trials showed that the power consumption was cut from 124 W to 24W.

The lamps are fabricated from AlInGap which allows them to put 10000 millicandles at a driver current of 20 mA. Guaranteed minimum brightness levels for members of the family range from 500-4000 millicandelas depending on colour and viewing angle.

The LED units are packaged in an optical grade epoxy resin loaded with ullraviolet-A and B inhibitors to reduce the effects—long-term exposure to direct sunlight. The lens structure of the LED grouping ensures that the letters and symbols in message panels appear consistently sharp and bright over the specified viewing angle (8,15,23 and 80). They come in four colours: amber (590 nm), PortLand orange (605nm), reddish-orange (615nm), and red (626 nm) with respective luminous efficiencies of 480,370,263 and 150 lm/W. In quantities of 1 million, the price will be 30 cents each. For further details contact: Hewlett Packard Co Inquiries, Box 58059, Santa Clara, CA 95052-8059; http/www..hp.com [*IEEE Spectr*,**33** (11) (1996) 83]. ❑

DSRM

World's first national DNA database at Birmingham, UK

The world's first national DNA database is set up in Birmingham, UK at the headquarters of Britain's Forensic Science Service (FSS) in Collaboration with British Police. This is acclaimed as perhaps the most significant scientific advance in the fight against crime since the introduction of fingerprints.The database will help in elimination of innocent suspects at an early stage, the automated linking together of unsolved crimes and the rapid identification of offenders, thus resulting in significant savings in resources of police and courts.

DNA profiling provides an advanced testing process that enables individuals to be positively identified from a specimen of their blood, semen, hair roots or other tissue. Thus a bloodstain recovered from a

crime scene could be directly compared to a suspects' hair sample. The vast potential of the DNA technology is made possible by the FSS's development of Short Tandem Report (STR) profiling technique. The developments in STR technique have resulted in a more sensitive and discriminating test, which can be applied to mouth swabs and hair roots, making large number of cost-effective DNA test possible with a rapid turn around time. Also STR profiles are eminently suitable for use with a computer database. It is estimated that about 135 000 DNA samples will be taken in the First Year of the existence of the database. The system has a capacity of processing 650 samples per day at a cost of 40 pounds per sample.

The database collects, stores and analyses the DNA samples from suspects. Similarly DNA profiles from samples recovered from the scenes of unsolved crimes will also be placed in the database. For a fresh profile, it is automatically checked for a match against existing records. If a match is found, the details of the suspect will be generated so that the police may investigate further. Whenever a sample is recovered from a crime scene and a profile developed, it is matched against the entries in the database, then details of the profile are generated for police for follow-up action; if no match is found, then the profile itself is placed in the database.

The FSS is among the largest forensic science organizations in the world employing over 500 scientists and deals with over 50 000 crimes in a year. It has over i50 years experience of providing training, consultancy and scientific support services to overseas customers [*Electron For You*, **28**(10)(1996)46-48]. ❑

DSRM

What really makes water wet?

Researchers at the University College London (UCL) and at the University of Berkeley, California (UBC) have now shown that water does not start to behave like a liquid until at least six molecules form a cluster. This apparently arcane research is of great practical value. It will help to understand how water interacts with and dissolves much larger molecules. It might also help to explain how water molecules help vital proteins to fold up into the correct shape.

David Clary and his student John Gregory at the UCL have probed "wateriness" by using a complex mathematical model called the quantum Monte Carlo method. They investigated clusters ranging in size from two to six molecules in order to evaluate their properties and compare them with the familiar properties of bulk water. They found that groups of five water molecules or fewer have planar structures. These would form films one molecule thick, rather than puddles.

But, adding a sixth molecule to the group, the cluster switched to a 3-*D* cage-like structure which mimicked the familiar properties of bulk water. As soon as researchers got sixth, it flipped over to 3-*D*, and that is why it suddenly had the properties of water.

Collaborators at the UBC, led by Richard Saykally, confirmed the theory by observing real clusters of between two and six water molecules with a powerful new form of laser analysis called vibration-rotation-tunnelling spectroscopy. With this technique, the Berkeley chemists could cool each cluster down to just 10 degrees above absolute zero. At this chilly temperature, with the clusters nearly immobile, the chemists could probe in fine detail the fundamental vibrations and rotations of bonds and atoms in each isolated cluster.

From these observations, the UBC team was able to measure two properties of the clusters to see whether they matched those in bulk water. First, they measured dipole moments, values that reflect the distribution of charge in a molecule. Secondly, they measured the distances between oxygen atoms in neighbouring water molecules in each type of cluster.

In both cases, clusters containing six atoms showed the closest match with bulk water. Both the dipole moments and the distances between oxygen atoms corresponded to what one sees in bulk water [*Science*, **275** (1997) p. 814; *New Sci*, **153** (No. 2069) (1997) p. 21]. ❑

HKK

Cheap spectacles for sight correction

Correcting the eye sight through lenses prescribed by an optician is very common and the WHO estimates that about a billion people need such correction. At the same time, it is also clear that many of these people have neither access to optician nor the capacity to pay them.

Atomic physicist, Dr Joshua Silver had given a solution for this problem by providing very cheap glasses which offer quality correction but, are not dependent on an optician's prescription.

The lens proposed by Dr Silver Comprises two membranes of transparent polyester sealed onto a carrying ring within a standard frame. A tiny duct allows the space between the membranes to be filled with liquid - currently water - by means of a syringe by varying the amount of liquid injected. The lens provides a power range of about +4 to -4 dioptres, a range of correction adequate for 80 per cent of the population. Once the optimal focus has been achieved, the syringe is removed and the duct sealed.

Dr Silver then worked on a way to make a lens of variable focus.

The lens works on the same principle as the lens in the human eye. Both are variable focus, and both systems are auto-focusing. The eye-brain is an adaptive system; when an image presents on the retina, it is read by the brain which then, automatically, adjusts the focal power of the lens to produce a sharp focus on the retina. Silver says his glasses are only an extension of that system. But these are designed only for adults.

The WHO proposes to field test the spectacles in several African Countries *[Appropr Technol*, **23**(2)(1996)13]. ❑

DSRM

Fuel cells race ahead

Alfred Tseung and his colleagues at the Chemical Energy Research Centre, Essex University have developed a fuel cell which could be used in electric cars and other vehicles to be produced in the next five years.

An inexpensive organic liquid such as methanol will be used which can be broken down to release hydrogen to feed the fuel cell. The problem with this system is that some carbon monoxide is released from the methanol when it is broken down. this unwanted by- product quickly poisons the Pt-based catalysts that are used to oxidise the hydrogen in the energy release step.

Tseung *et al.* claimed to have solved the problem of catalyst poisoning, which may open future transport to the benefits of a clean fuel that is 15 to 18% more efficient than petrol.

A way has been found to get rid of carbon monoxide before it poisons the catalyst. This catalyst contains an extra ingredient, tungsten trioxide, which has the ability to break down carbon monoxide by oxidising it to harmless carbon dioxide. This, the Pt catalyst can handle a stream of hydrogen derived from the methanol containing as much as 2% carbon monoxide.

The results show that there is no poisoning for hydrogen containing 100 ppm CO at an anodic potential of 0.2 V vs SHE (Standard hydrogen electrode). However, at lower potential or at higher CO concentration, there is poisoning. At the same potential, the performance of hydrogen containing 2% CO is eight- times lower than that for 100 ppm CO.

Topping up with methanol at the filling station will allow the car to go twice as far as its petrol and diesel counterparts. In the long run, however, the coal and natural gas from which the methanol is derived will run out and researchers will have to find alternative ways of carrying packaged hydrogen. Catalytic Electrodes has provided funds for patenting the invention worldover [*Chem Brit*, **33** (2) (1997) p. 19]. ❑

HKK

Portable equipment to identify plastics for recycling

Recycling of plastics assumes great importance in the protection of environment.

Peter Mucci and his colleagues at Southampton University's Department of Mechanical Engineering, based on technology developed by the World's first mobile spectroscopic plastics identification service was developed and launched in Manchester at the Royal Society of Chemistry Conference on Plastics recycling.

Called 'Portasort', the system offers rapid identification of plastics for recycling and requires no special knowledge from its operator. The service is mobile and can be used from the back of a small estate car or can be installed on the factory floor.

The system consists of a patented infrared unit backed up by a database of all commonly used plastics. Once a sample is subjected to scanning, portasort enables the operator to identify the type of plastic—whether it is from a bottle top or from a car bumper. A print out can be had showing all items tested and a list of recommended purchasers of that particular waste plastics that is scanned. Portasort

service is offered by Index Logistics Ltd. of Petersfield.

Plastic recycling industry is still in its infancy and it is hoped that Portasort offers an economical means to have their own laboratory analyzers. Further information can be obtained from: University of Southampton, University Road, Highfield, Southampton, England SO1 71BJ [*Brit Comm News*, November/December 1996, p. 34]. ❑

DSRM

Road surface coatings reduce automobile pollution

Scientists at Mitsubishi Materials Division are carrying out research to fight the automobile pollution and noise pollution on highways.

The Mitsubishi researchers have developed a road surface that destroys the nitrogen oxide pollutants emitted in car exhausts. A semi-permanent layer of titanium dioxide developed by them was applied to the surface of concrete paving blocks. In sunlight the titanium dioxide catalyses UV destruction of NO_x compounds in the air layer nearest the road. The thin film of nitric acid formed during reaction washes off the blocks next time it rains.

Tests conducted by the team showed that the coated surface can remove 80 per cent of NO_x from air in a closed vessel. The effectiveness of the pressed concrete blocks is being tested on a busy stretch of road in Osaka on a 50 m^2 of paving blocks. The blocks will be manufactured through a network of franchise companies. Cost-wise the product is priced about £ 60 per m^2 which is comparable with other high-quality paving materials. Once these trials prove fruitful, it is expected that highways in Japan will become the least polluting motorways in the world [*Chem Brit*, **33** (2) (1997) 18]. ❑

DSRM

High-temperature materials require new coatings

Researchers at the National Research Council's Commission on Engineering and Technical Systems, have developed new technologies which have created a broad range of heat-resistant materials, gas turbines which now operate at temperatures much higher than a decade earlier. Currently used coatings are unable to withstand the heat. Earlier, technologists usually picked high-temperature coatings after designing blades, vanes, and other turbine components.

Now, the component and coatings must be designed hand in hand. In some proposed designs, the coating and substrate form a continuum, literally blurring the boundary between the surface deposit and the material it coats. The propulsion systems were considered for commercial and military aircraft and their marine and industrial versions. Particular attention was paid to the coating needs of ceramics, intermetallics, and other substrate materials being considered for future engine designs.

New coatings will most probably have graded compositions and multiple layers. It is also suggested that work should be done into coatings with built-in sensors and embedded microchannels that contain streams of cooling fluids [*Des News*, **51**(13) (1996) p.18]. ❑

HKK

New surfacing brings instant repairs to roads and runways

Emcol International, Hertfordshire, UK, has developed a material by use of which permanent repairs to roads and airport runways can be made instantly. The surfacing can be used in conditions ranging from very dry to very wet and from +40 to - 40°C. It is claimed that within seconds of application, it will be possible to drive heavy vehicles or to land aircraft on the repaired surface.

The material, called *Emcol IRR*, can be used for cost-effective repairs to asphalt, macadam, concrete and other surfaces. It abuts well to metal and composite materials and is not subject to shrinkage, stripping or liquid/aggregate separation. The material which comprises a combination of selected aggregates and a binder liquid based on penetration bitumens, resins, adhesives and other additives, is applied cold without the use of hot-laid asphalt.

Emcol IRR is also widely used for in-filling cable ducts, trenches, core holes, access-cover surrounds and drains, ramping concrete-slab-corner repairs and for jointing. Packed in 25 kg resaleable buckets, the product has a storage life of ten months and is cold applied straight from the pack. It needs no tack coats, overbanding or special equipment.

Two grades are available. The standard grade is for repairing holes greater than 10 mm in depth and the largest aggregate is 6 mm. The fine grade, in

which the largest aggregate is 3 mm, is for repairing holes 75 mm in depth and for jointing, concrete repairs and repair of slab corners [*Spectrum*, **No. 255** (1996) p.4]. ❑

HKK

Genetic clue to high blood pressure

Dr Paul Steward *et al.* at the Department of Medicine, Birmingham University, English Midlands have found a defective gene in two young brothers who had a rare form of high blood pressure. Their parents were healthy, but were first cousins and the boys had inherited one copy of the gene from each.

The gene normally makes an enzyme that converts the stress hormone cortisol into active cortisone. The children lack this enzyme and the excess cortisol interferes with the uptake of another adrenal hormone, aldosterone. Aldosterone is important in controlling salt levels and therefore blood pressure, and by blocking a normal blood pressure control route the cortisol causes high blood pressure.

Although the gene defect is very rare, it is believed it could be much more widely relevant to the problem of high blood pressure. Up to one-third of people with high blood pressure have some evidence of inappropriate salt retention. Although they would not have a full-blown defect, it could be established that abnormalities produce an enzyme that fires on two cylinders rather than four.

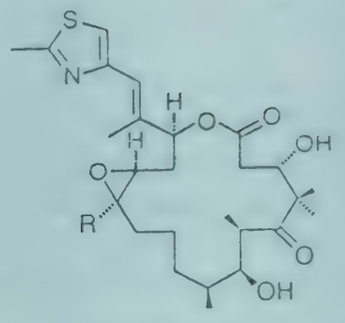
The Birmingham team is now looking at high blood pressure sufferers to see if they are converting cortisol to cortisone normally. The work could result in new drugs. Even with the presently available drugs, in many cases of hypertension one could do a much better job if he knew what the underlying defect was. ❑

HKK

First synthesis of new anticancer agent

Samuel J Danishefsky *et al.* at the Sloan Kettering Institute for Cancer Research, New York, in collaboration with workers at the Columbia University have carried out first total synthesis of epothilone A [*Angew Chem Int Ed Engl*, **35** (1996) p. 2801].

Epothilone A a bacterial natural product has been attracting considerable interest as a potential anticancer drug. The compound, epothilone A, and the related structure, epothilone B, seem to be more



Epothilone A, R = H
Epothilone B, R = CH_3

potent than the commercialized anticancer drug paclitaxel, having the same mechanism of action.

The epothilones were discovered in the late 80s by Gerhard Höfle and colleagues at the National Biotechnology Research Institute, Braunschweig, Germany. After Höfle reported the X-ray structure of the compounds in early 1996, a competition began to carry out the first synthesis.

Epothilone A was synthesized first because it is an easier synthetic target than epothilone B. It is hoped that the synthesis will make it possible to create analogs of epothilones that are more active than the natural products [*Chem Eng News*, **74** (51) (1996) p. 10]. ❑

HKK

Fitness test for hormones

The hormones are involved in regulating basic body functions from pregnancy to potency. It is, therefore, often crucial to know whether these essential substances, which may be present in extremely low concentrations are performing properly. A new approach developed by researchers at the Weizmann Institute, Israel, has tackled this problem.

To evaluate hormonal function, it is necessary to determine whether the hormone can bind to specific receptors on target cells, and whether this binding causes the cells to produce certain substances. Such testing is complicated because the natural target cells are usually short-lived and have relatively few appropriate receptors.

This difficulty has been overcome by genetically engineering "immortal" ovarian cells, which reproduce endlessly in laboratory conditions, and equipping them with large number of suitable receptors. These cells were used to test the biological activity of gonadotropin hormones, involved in regulating ovulation, sperm maturation and sexual develop-

ment. Three major indicators were successfully assessed: (i) binding to cells, (ii) production of a vital chemical messenger called cyclic AMP, and (iii) the resultant release of progesterone, a product of ovarian cells that is essential for maintaining uninterrupted pregnancy.

The new method is also adapted for testing the activity of catecholamines, the group of hormones that includes adrenalin, which regulates heart beat and blood pressure. Besides medical diagnosis it also holds promise for use in various fields, including the hormonal testing required for animal breeding. ❑

HKK

Presentation of technical communications in journals

Technical writing is an art and editors of scientific and technical journals in variably have to change the manuscripts regarding their presentation and clarity. A number of institutes are engaged in imparting training in good technical writing, the topics dealing with English grammar, style, units, symbols, word processing, graphics presentation, etc.

Kathryn S Brown analyses the experiences and suggestions of editors of leading medical journals. Now retired as a senior editor at JAMA, Lester King has written a book *Why Not Say it Clearly: A Guide to Expository Writing* (Boston, Little, Brown and co. 1978) reflecting his experiences as a journal editor in cutting vague words, sniping long sentences in the manuscripts submitted for his journal. He expressed " I could not believe the amount of correction I had to do". Ever since the first journal has emerged in 17th century editors as well as authors, have noticed that the reader has to 'trudge though needlessly wordy journal writing'.

Journal editors have styles of their own to present a title, abstract, reference and the other components of a research paper in addition to the baffling acronyms, abbreviations, units etc. Another deep rooted tradition is to report the results in the so called objective way - every thing in passive voice.

The reasons for the observed painfully dense prose in journal writing, Brown, observes, are the pressure to publish new results quickly, or the authors tamely following existing journal style. The latter fact is attributed for the sake of its quick publication.

All journals do publish in their instructions to authors how to submit a paper. But the lengthy, jargon filled technical writing is possibly due to the anxiety of authors to communicate much before their competing camps as in biology, in particular genetics to uncover a gene. Former editor of *British Medical Journal*, Stephen Lock Observes "if people weren't so paranoid to be the first out with a new finding, the writing may be better". So authors put down their ideas in a frenzy throwing the style to winds. Others who care for style and language present their paper in the same style of the journal to which it is submitted to ensure its publication. Thus, over years the "Wooden and Wordy" style was perpetuated. The use of active voice, short sentence and first person reporting — all generally invite criticism of reviewers following the rigid style followed over a long time. Since career promotion is linked to the number of publications to one's credit, young professors stop trying to write journal articles in clear original style saying "it is risk avoidance".

Majority of scientists conform to passive voice avoiding the use of pronoun "I" or sprinkling their paper with some colourful or stylish words. Although the reason may be traced to the belief that the authors want to appear detached and objective in their work, Rebecca Chasan, editor of *Bioscience* feels "too much of it just makes an article too hard to read".

King points out in his book that the use of passive voice forces the reader to pause and spend some time in finding out who was doing that action.

The other factors that may impair the clarity of running text in a technical paper appear to be subject/verb separation— in the extreme case separated by as many as 20 words or so—, and indiscriminate and excessive use of abbreviations. At a level higher than words and sentences, lack of organization of the text in well connected paragraphs which according to former editor Edword Huth may lead the reader to get hopelessly lost from its start if it happens in introduction section of the paper.

In the opinion of editors and writing teachers, authors benefit from focussing on their statements if they "lay it out for the reader". At sentence level the advice is: avoid excess jargon and abbreviations; keep the sentences short; keep subjects and verbs together; choose simple verbs; use the passive voice sparingly; and cut redundant words or phrases.

The general feeling of editors is that every scientist who contributes a paper to a learned journal should revise it, discuss and circulate among colleagues for harshest criticism. According to King, "the important thing is not writing but rewriting". This will increase their chance of attracting readers as well as editors [*The Scientist*, **11** (2) (1997) 16-17]. ❑

DSRM

International Commission for Optics Prize

The 1996 Prize of the International Commission for Optics has been awarded to Vladimir Buzek.

He is recognized for his contribution to the development of quantum optics from the theoretical standpoint. Buzek's work is in the area of theoretical quantum optics and currently he is at the Slovak Academy of Sciences. He has investigated the origin of squeezing and other non-classical effects like sub-Poissonian Photon Statistics and oscillation of Photon number distribution produced by the superposition of coherent fields; the non- classical effects in atom-field interactions and the effect of AC Stark shifts on the dynamics of atoms interacting with a near resonant quantized single mode cavity field which is of relevance to single atom, micromasers.

In addition, he has investigated the influence of atomic spontaneous emission decay on the collapse revival phenomena in the optical region; the photon statistics of non-classical fields in a linear directional coupler; and the statistical & phase properties of output states of Mach-Zehnder interferometry with a non-linear Kerr medium in one of its arms [*Opt Laser Technol*, **29**(1)(1997)iv]. ❑

DSRM

Information Society Forum of the European Commission

The European Commission decided to set up the Information Society Forum in February 1995 in order to create a new and authoritative source of reflection, debate and advice on the challenges of the Information Society.

The Forum consists of 128 members drawn from five main fields of activity:

* Users of the new technologies: industry (banks' retail, maritime etc), public services, consumer groups, small and medium-sized enterprises and the professions

* Social groups: academics, employers organisations and trade unions, youth groups, regional and city representatives

* Content and service providers: publishers and authors, film and TV producers, broadcasters, computer software producers and information service providers

* Network operators: fixed telecommunications, cable TV, mobile and satellite operators

* Institutions: members of Parliament, of the Economic and Social Committee of the Committee of the Regions and the data protection Commissioner.

Six working groups have been formed whose members have given their views under the following heads:

* the impact on the economy and employment;

* basic social and democratic values in the "virtual community,"

* the influence on public services

* education, training and learning in the Information Society

* the cultural dimension and the future of the media

* sustainable development, technology and infrastructure

The European Commission has published the first Annual Report and the supplementary report (working group's reports) which can be obtained from the Information Society Forum Secretariat (European Commission, Information Society Activity Centre, 200 Rue de la Loi, BU 24, 2/70, B-1049 Brussels. The full texts are also available on the ISPO web server at: URL: http:/vww. ispo. cec be/info-forurm/pub.html

Summary of the report of Working Group I under the head "The Impact on the Economy and Employment" is given in this issue. The other reports of the Working Groups will be covered in subsequent numbers of JSIR one in each issue .

Summary of Report of the Working Group 1: The Impact on the Economy and Employment

The Impact on Growth

Economic analyses and historical evidence show that technological change is a factor stimulating growth. The impact of Information and Communication Technologies (ICT) on growth will be significant and positive. But profound structural and institutional changes are required to allow the potential impacts to materialize and, unfortunately, these changes are taking place slowly, giving rise to a number of misadjustments. The emergence of the Information Society will effectively depend on its social acceptability. A coherent conceptual framework is lacking in order to facilitate quantitative and qualitative assessments of the phenomenon, identify the obstacles, and shape policy recommendations.

The Information Society will make a considerable contribution to sustainable development by enabling growth to be based more strongly on the accumulation of knowledge and on intangible factors. It will allow the contradiction between continuity of growth, scarcity of resources and preservation of the environment to be resolved. The mechanisms and safeguards assuring an organised transition must be implemented rapidly because they are a precondition for social acceptance of the Information Society.

The Impact on Employment

In the medium to long term, the Information Society will contribute to job creation, even if job reductions could occur in the short term,. In particular, the job reductions in Europe necessary for European telecommunication operators to reach the USA benchmark in terms of employees per lines is estimated to be between 250,000 and 300,000.

Direct and indirect job creation attributable to the Information Society is difficult to quantify because many factors are uncertain and a reliable method is lacking.: For France, the T. Breton report expects between roughly 60,000 and 200,000 job creations in "teleservices" within a 10 year period.

Given the current unemployment situation in Europe, priority should be given to a better understanding of the process of job creation by focusing on questions such as where will new jobs be created and with which skill requirements?

Sectors of potential new job creation include media creation, software production, including educational software, adding value to and exploiting cultural heritage, improvements in environmental control and in energy efficiency, distance learning services, remote medical services and other services aiding the expansion of regional SME's.

Further investigation should aim to identify the concrete sources of job creation in Europe and to understand how better use of ICT may create jobs across most sectors. In order to maximise the positive impact of the new technologies on employment, the Working Group considers it a priority to diffuse knowledge of best practices in the use of ICT, in education and training, and in the experimental use of applications and services.

The Impact on Company Organisation

As the Information Society develops, company organisation will evolve in the direction of vertical disintegration, teleworking and decentralisation and be based on allocating nonstrategic activities to external suppliers so as to increase flexibility. At the same time, companies will be keen to develop economic intelligence allowing them to anticipate market trends.

The pace and scope of corporate adaptation to the Information Society will be crucially influenced by changes in the technological and regulatory environment as well as by the rapidity with which economic and social policies are adjusted. Both public authorities and companies could have a greater impact on the supply of ICT services and tools.

SME's are confronted with specific obstacles such as the inadequacy of generic tools and services, lack of information on the available technologies, standards and markets, difficulties in investing in human resources, and tougher and tougher competitive pressures in their local markets.

Teleworking: A Combination of Telecomnetworking and Tele-Homeworking

The implementation of teleworking goes hand in hand with numerous other changes. The traditional organisation of work ties both the rights and obligations of employers and employees to work performed within the company. Consequently, teleworking requires different social and legal frameworks.

The Working Group identified a series of legal and regulatory obstacles to the development of teleworking: lack of a conclusive and statutory definition of the concept of "teleworking" which would allow, among other things, the application of labour law regulations; the possibility that the current concept of "employee" might encourage social exclusion; the need to adapt regulations protecting safety and health; the absence of financial compensation arrangements for the use of domestic premises; rights of access to domestic premises for employers and relevant work inspectors despite the basic principle of the sanctity of the home; the need to adapt rights governing trade union representation; the absence of global agreements on minimum standards for teleworkers on the basis of International Labour Organisation (ILO) standards including elements such as the right to establish and join organisations, the right to participate in collective bargaining, protection against discrimination in employment and within the relevant profession, industrial safety and health in the workplace, pay, social protection and education and training opportunities. [First Annual Report to the European Commission from the Information Society Forum, European Commission, Information Society Activity Centre, 200 Rue de la Loi, BU 24, 2/70 B-1049, Brussels, June 1996].

Announcement

International Conference on Frontiers in Biotechnology

A four day conference on 'Frontiers in Biotechnology' is being organized by Regional Research Laboratory (RRL), CSIR, Trivandrum in collaboration with Department of Biotechnology, New Delhi, India, during November 26-29, 1997 at RRL, Trivandrum, Kerala, India.

The programme of the Conference comprises Plenary (40 min) and Invited lectures (25 min) and poster sessions for contributory papers. The areas covered are: (i) Industrial Biotechnology, (ii) Food and Pharmaceuticals, and (iii) Environmental Biotechnology. Major topics proposed to be discussed are:

- Cell Biology and Genetics
- Microbial Cultivation Systems
- Solid State Fermentation
- Microbial Production of Value Added Products
- Bioprocess Development
- Downstream Processing
- Microbial Synthesis and Chemistry of Bioactive Compounds
- Fat and Lipid Biochemistry
- Biosensors
- Biodiversity
- Eco-friendly Products and Processes— Biofertilizers, Biopesticides, Biopolymers, Biopulping, Bioleaching Bioremediation and Biotransformations
- Biodegradation of Environmental Pollutants
- Biological Detoxification
- Waste Management

Participation is open to anyone involved in Biotechnology R&D, Planning, Consultancy, etc., worldover. In order to encourage participants from the universities, special rebate in registration fee will be offered to them. Registration fee up to 31 August 1997 is Rs 2500.00; US $ 200.00 and after this date: Rs 3000.00; $ 250.00.

For further details contact:

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Journal of Scientific & Industrial Research
(Incorporating *Research and Industry*)
Instructions to Contributors

The **Journal of Scientific & Industrial Research** (Incorporating *Research and Industry*) is published monthly to serve as an information link between the generators and users of technologies. It is addressed primarily to industrial entrepreneurs, technologists, engineers, technocrats and administrators in industry. Therefore, original research articles of practical interest to industry are invited for publication.

Contributions should have an economic bias, and wherever possible, cost estimates should be provided. They should be tersely written, giving only the significant results.

Besides, reviews on various branches of science and technology, science/industrial policy and management are also accepted.

Subject Coverage

Scientific Industrial Research

(i)Scientific investigations successful at the pilot-plant and in-plant trials.

(ii)Technology upgradation.

(iii)Development of cheaper and indigenous raw materials as replacement for uneconomical materials.

(iiv)Import substitution.

(v)Technologies for rural development.

(vi)Standardization and quality control.

(vii)Technologies of waste management.

(viii) Industrial R&D highlights.

Technology Management

(i)Success/failure stories in technology management.

(ii)Technology assessment.

(iii)Technology transfer.

(iv)Technology assimilation and adaption in different industries.

(v)Technology funding including venture capital.

(vi)Human Resource Development.

vii)Management.

(viii) Environmental management.

Industrial Development

(i)Policies, programmes and progress.

(ii)Critical profiles of industries—individual and sectoral.

(iii)Technology Forecasting .

(iv)International Collaboration.

(v)Fiscal incentives aimed at industrial development.

Books, monographs and technical bulletins on industrial methods and techniques as well as other data like production and demand statistics are accepted for review.

A critical analysis of papers presented at any Indian as well as international technology seminar/ symposium is also welcome.

Questions on the articles published in the journal, answers supplementing any of the published items, views, opinions, or suggestions on the various aspects of technology are welcome for inclusion in the column, 'readers react'.

The editors are keen in projecting the technology bottlenecks/problems faced by the industry for their solution by the scientists in various laboratories. They would welcome to be mediators between the industry and the laboratory.

Preparation of Manuscript

Manuscripts should be presented in electronic form as well as in hard copy. Pages should be numbered consecutively, and the matter should be arranged in the following order: title; name(s) of author(s); department(s) and institution(s); abstract; keywords; introduction; materials and methods; results and discussion; acknowledgement; and references. The abstract, tables and captions (for figures) should be typed on separate pages.

The electronic form of the manuscript should be submitted on a floppy disk of 5¼" (1.2 MB) or 3½ (1.44 MB) to the Editor along with one hardcopy print out and one xerox copy. Text of the manuscript may be entered using word processing softwares such as Word Perfect Version 5.5/6 or MS Word Version 6 (preferably on IBM compatibles) and for illustrations Corel Draw, Harvard Graphics or any compatible format software (BMP, GIF, JPG, PCX, TIF) may be used. Label the floppy disk with the author(s)' name(s), the word processing package, software for illustrations, and the type of computer. In case of discrepancy between the disk and the manuscript, the latter will be taken as the definitive version.

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Abstract—The abstract, usually not exceeding 200 words, should indicate the scope and method used in the paper, highlighting the principal findings and conclusions

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Materials and Methods—New methods should be described in sufficient detail, but if the methods are already well known, a mere reference to them will do; deviations, if any; should however be stated.

Results and Discussion—Only such data as are essential for understanding the discussion and main conclusions emerging from the study should be included. Data should be arranged in a unified and coherent sequence so that the report develops clearly and logically. The data should be statistically analyzed, and the level of significance given. The same data should not be presented in both tabular and graphic forms.

The discussion should deal with the interpretation of results. It should relate the new findings to the known, and include logical deductions.

Acknowledgement—This should be brief and for special assistance only, not for routine 'permission' to publish, or such trivial formalities.

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In citing ***references to research papers***, names and initials of the authors should be followed, in order, by the title of the periodical in the abbreviated form (italics), the volume number (bold), the year within circular brackets and the first page reference ,e.g. Liotta R, Rose K & Hippo`E, *J Org Chem*, **46** (1981) 227

For names of periodicals, the standard abbreviations listed in the *International Serials Catalogue* published by the International Council of Scientific Union's Abstracting Board should be used If the reference is to an article published without any

authorship in a periodical, the title of the artilce takes the place of the author in the citation, e.g. Handloom Sector of Textile Industry in India, *J Mater Sci*, **18** (1983) 1443.

If a paper has been accepted for publication, the names and initials of the authors and the journal title should be given followed by the words "in press" within circular brackets, e.g. Chavan R B & Subramanian A, *J Sci Ind Res*, (in press).

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Reference to a thesis should include the name of the author, title of the thesis (italics), university or institution to which it was submitted, and year of submission, e.g. Ghosh G, *Ph D Thesis, Structure of Coal*, Jadavpur University, Calcutta, India, 1984.

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POSITION: DIRECTOR, INSTITUTE OF MICROBIAL TECHNOLOGY (IMTECH), CHANDIGARH.

CSIR, the premier agency established by the Govt. of India to undertake scientific and industrial research in the country, is looking for suitable scientist/technologist for the post of Director for its Institute of Institute of Microbial Technology (IMTECH), Chandigarh. IMTECH is devoted to provide an integrated research, development and design base for microbial technology; to undertake basic and applied research and development programmes in established and newly emerging areas of biotechnology including genetic engineering; to develop and maintain gene pool resources and genetic stocks of microbial cultures and other cell lines; to impart training in microbiology, microbial technology and biochemical engineering to research workers and technolgists; to establish and maintain effective linkages with industry and educational institutions, develop capabilities for producing design and engineering packages for industrial plants and to undertake contract work on research and development in the areas of biotechnology. The Institute carries out application-oriented R&D in the frontier areas of biotechnology with the short-term objective of capability generation and a long-term perspective of generating newer leads in the critical areas of its working. Most of the research programmes deal with the application of newer tools of molecular biology and genetic engineering to develop new technolgies or improve upon the existing ones, vital to out national needs. The Institute is currently carrying out R&D programmes in the following areas: molecular biology and microbial genetics, animal cell/tissue culture, protein engineering and fermentation technolgy. The Institute undertakes contract work for development of microbial processes for useful products.

The Institute has an annual budget of about Rs. 600 lakhs and S&T staff of approximately 140 out of which about 40 are scientists.

The post carries the pay scale of Rs. 5900-200-7300 plus allowance as admissbile to Council employees. The appointment to the post will be on contract for a period of six years or superannuation, whichever is earlier.

For further details, please contact the Director-General, CSIR, Rafi marg, New Delhi-110001 (INDIA), (Fax - 3710618, Telex-031-65202 CSIR IN, 031-66147 CSIRIN, Gram-CONSEARCH, New Delhi).

Interested candidates may send complete biodata by 30th May, 1997 to the Director-General, CSIR, Rafi Marg, New Delhi-110001.

COUNCIL OF SCIENTIFIC AND INDUSTRIAL RESEARCH (CSIR), NEW DELHI, INDIA.

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POSITION: DIRECTOR, INSTITUTE OF HIMALAYAN BIORESOURCE TECHNOLOGY, (IHBT), PALAMPUR.

(FORMERLY KNOWN AS CSIR COMPLEX, PALAMPUR.)

CSIR, the premier agency established by the Govt. of India to undertake scientific and industrial research in the country, is looking for suitable scientist/technologist for the post of Director for its Institute of Himalayan Bioresource Technology (IHBT), Palampur. IHBT is devoted to conduct basic and applied research on economic plants; to research relevant to plantation, forest, agriculture and horticulture produce with a view to value addition and providing technological support for the development of the existing and new industries in the Northern region of the country; to assist the growers and industrialists through consultancy, contract research, training etc. The major R&D programmes of the Institute relate to floriculture, tea sciences, biotechnology, natural plant products and biodiversity. The Institute offers consultancy services to researchers, industry, and growers on : development of economic plants, project formulation and evaluation, and database search services in the area of tea, medicinal and aromatic plants biodiversity and tissue culture and other biotechnological techniques for propagation of these plants. The Institute also organises training programmes on agrotechnologies and processing technologies for tea, essential oil-bearing plants, cultivation of flowers for commercial purposes, efficient management/regeneration of rare plants and tissue culture methodlogies.

The Institute has an annual budget of about Rs. 355 lakhs and S&T staff of approximately 75 out of which about 25 are scientists.

The post carries the pay scale of Rs. 5900-200-7300 plus allowance as admissbile to Council employees. The appointment to the post will be on contract for a period of six years or superannuation, whichever is earlier.

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COUNCIL OF SCIENTIFIC AND INDUSTRIAL RESEARCH (CSIR), NEW DELHI, INDIA.

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POSITION: DIRECTOR, NATIONAL BOTANICAL RESEARCH INSTITUTE, (NBRI), LUCKNOW.

CSIR, the premier agency established by the Govt. of India to undertake scientific and industrial research in the country, is looking for suitable scientist/technologist for the post of Director for its National Botanical Research Institute (NBRI), Lucknow. NBRI is devoted to carry out R&D on conservation, improvement and exploitation of economic plants, including ornamentals; to carry out basic and applied botanical, horticultural and related phytochemical research on plants and plant products and to develop production technologies for new plant sources of commercial importance. The major R&D programmes of the Institute relate to plant biotechnology, floriculture, tree-biology, plant wealth utilization, environmental sciences and taxonomy & ethnobotany. Major thrust area programmes of the Institute are directed towards: (i) basic and applied research in plant molecular biology, biochemistry and stress physiology; (ii) standardisation of agrotechniques and package of practices for ornamental plants for nursery and cut-flower trade and development of new cultivars; and (iii) development of production and nursery technology for woody biomass and energy plantation on sub-standard soils. The Institute offers consultancy services to industry/government organisations in garden layout and landscaping and in other related areas.

The Institute has an annual budget of about Rs. 800 lakhs and S&T staff of approximately 600 of which about 115 are scientists.

The post carries the pay scale of Rs. 5900-200-7300 plus allowance as admissbile to Council officials. The appointment to the post will be on contract for a period of six years or superannuation, whichever is earlier.

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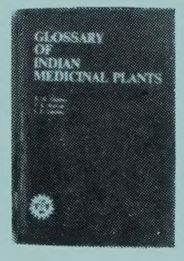

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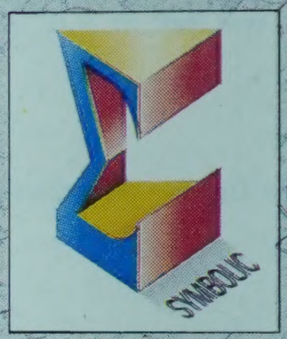

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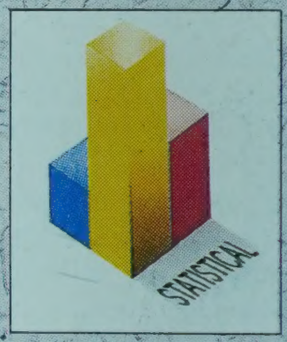

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